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CONTENTS

PROGRESS REPORT ON THE ANTARCTIC ICE SHEET

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CONTENTS

Introduction

The art, science and sport of conducting scientific traverses across the Antarctic continent has advanced so rapidly during the past decade that we are making considerable progress towards understanding the main characteristics of that continent and its ice mantle. Many reports of recent work are provisional, so some changes of detail in the following account may eventually prove necessary. Nevertheless, some major features are now well established, such as the great depth of the subglacial floor to the east of the Ross Sea, and the observations that show considerable sections of the rock of East Antarctica† to be above sea level. On the other hand, the past glaciological history of the continent and the state of the present mass balance of the ice sheet still need much more investigation before we can be satisfied with the answers. The continued activity in Antarctica should result in our knowledge of the continent advancing much further during the coming decade.

Surface features of the ice sheet

Estimates of surface height have proved to be most reliable when made by surface parties. Nevertheless, techniques of height measurement based on barometric pressure at a location separated by some hundreds of miles from other stations may introduce considerable errors in spite of corrections for the geostrophic wind. Alt, Astapenko and Ropar[1] point out that on 1 August 1958 the official heights of "Sovetskaya", "Vostok" and "Komsomol'skaya" for meteorological purposes were lowered by the order of 100 m., which gives some indication of the difficulty of making determinations with sufficient accuracy. The system of barometric profiling using a step-by-step technique, with one vehicle remaining at a check point until a barometric comparison with the next stop on the traverse has been completed, has resulted in some very small errors of closure when used by United States parties[2] (e.g. 3 m. on the "Byrd" traverse in 1957–58). After corrections for wind gradients between observing points have been applied, the absolute heights on the Ross Ice

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† In this article the term "West Antarctica" is used to denote the Pacific Ocean side of a line joining the south end of the Ross Ice Shelf to the south end of the Filchner Ice Shelf. The remainder of the continent is referred to as "East Antarctica".

Sub-glacial floor

+ Above sea level

– Below sea level

⊥ Below sea level but would rise above sea level after ice load was removed

Thickness of earth's crust by seismology (see p. 7)

—— Normal continental thickness

- - - - Equivalent to ⅓ continental plus ¼ oceanic thickness

Surface heights of ice sheet are shown in metres.

Sketch map of Antarctic ice sheet

Shelf traverse of 1957–58 look realistic,[3] and as these appear to check with the ice thickness measurements the technique is probably the most accurate one in use in Antarctica, although systematic errors on the inland slopes of Antarctica may be larger than on the ice shelf. The slower but accurate technique of surface levelling by optical methods, as used on the British North Greenland Expedition,[4] has not, however, been applied over a large distance in Antarctica.

A recent paper by Gusev[5] indicates that Russian scientists have been attempting to improve methods of surface profiling by use of aircraft and radio altimeters. By flying above the cold surface inversion the aircraft height determination by standard barometric methods is made more accurate, since corrections for horizontal temperature gradients within the cold inversion layer cannot be estimated with much accuracy. However, the Russians are also developing two other methods of determining the aircraft height from a record of the vertical movement of the aircraft on tape throughout the flight. The first system measures the vertical velocity from the change in air pressure due to the rise or fall of the aircraft, while the second system employs an accelerometer, the output of which is twice integrated to give the vertical displacement of the aircraft. The latter method has the advantage that it is independent of atmospheric pressure variations if sufficiently refined instruments can be developed for accurate measurement. The inherent difficulty with all aircraft methods of surface altimetry is that of knowing the exact co-ordinates of the surface point being measured. Although sufficiently accurate radio methods of navigation for such a purpose exist, they do not appear to have been used to any great extent in Antarctica.

Some surface heights which have been measured by surface parties are shown on the map. Major features discovered as a result of I.G.Y. activities include the dome shaped nature of "East Antarctica" rising to a maximum elevation of 400 m. The domed shape is, however, slightly modified by the underlying relief, in spite of the thick ice cover. In general the thicker the ice, the less effective is the underlying relief in modifying the surface features of the ice sheet. Consequently coastal areas are those in which the pattern of ice cover indicates the underlying relief most clearly.

One other generalization in regard to the surface relief of the ice sheet is that its height increases continually as one moves inland along a line of flow of the ice. However, very high mountains can act as effective dams and divert the ice flow elsewhere. Crary[6] considers it likely that drainage of plateau ice through the mountains west of the Ross Ice Shelf is not significant.

Another major feature discovered during the past five years is a large depression of the snow surface in "East Antarctica", which indicates that a huge drainage basin feeds into the Lambert Glacier and Mackenzie Bay. This basin is probably not due so much to the underlying relief as to the extension of the Amery Ice Shelf to lat. 71½° S.[7] This provides a drainage "sink" at about sea level, some 300 miles south of the main run of the coastline of this section of "East Antarctica", thus lowering the level of the surrounding ice sheet to form the basin. In "West Antarctica", snow-surface elevations of over

2000 m. between the Sentinel Mountains and the Horlick Mountains[8] eliminate the possibility of any low-level surface connexion between the Weddell Sea and the Ross Sea. The largest section of the continent not yet seen, even from the air, is an area of over half a million square miles between the Pole of Inaccessibility and the eastern coast of the Weddell Sea.

Ice thickness

The combination of seismic soundings every 30 to 50 miles, supplemented by much more frequent gravity measurements, as described by Woollard,[9] has proved the most efficient technique during the I.G.Y. for obtaining ice thickness profiles during scientific traverses. The technique has been employed on nearly all the major traverses made recently, and need not be described here. The anticipated difficulties of obtaining seismic reflexions when shooting on the high inland plateau of Antarctica were met, but have been sufficiently overcome by deeper shot holes and improved instrumentation for results to be obtained at most stations.

Preliminary results of ice thickness measurements have now appeared in one form or another [6, 8–15] for most of the traverses completed up to the 1958–59 season. They indicate that the mean thickness of the Antarctic ice sheet, neglecting coastal areas and ice shelves, may well exceed 2000 m. The rock surface under the ice varies considerably in character between different regions, being relatively flat in some parts of Marie Byrd Land but a rugged relief in other parts is common. This is particularly the case in the vicinity of exposed mountain ranges, such as near the Horlick Mountains and the Sentinel Mountains and in Dronning Maud Land, but some relatively rugged regions are completely ice covered, such as a mountain reported to rise 3000 m. above sea level some 300 km. north-east of the Pole of Inaccessibility.

The map shows the picture of the structure of the Antarctic continent which is emerging from the preliminary results. The areas where the subglacial floor is above or below the present sea level, when coupled with our knowledge of the areas of exposed rock, clearly indicate that the main bulk of "East Antarctica" is of continental proportions, although great areas would be flooded by the sea if the ice could be removed suddenly. However, evidence from past ice ages in the northern hemisphere indicates that, during the slow and gradual melting of the Pleistocene ice sheets, the rock surface gradually rose as the load of ice was removed in such a way that the total mass of the ice lost was replaced by an approximately equal mass of rock. Such compensation takes place on a regional basis, so that local features such as the mountain and valley relief remain, but a general upwarping over hundreds of miles occurs. A modified symbol has therefore been used in the map, showing areas below the present sea level which would nevertheless be expected to rise above sea level after adjustment had taken place if the Antarctic ice sheet were to disappear.

On taking this adjusted sea level into account, it appears still more certain that "East Antarctica" is a continental block. However, the position in "West Antarctica" is still not clear. This has been discussed by Thiel, Ostenso and

Bentley[8] who show that the existence of a deep trough connecting the southern part of the Ross Ice Shelf with the Bellingshausen Sea is probable. To the west of this region volcanic rocks are believed to be typical of an island zone, while to the east geological similarities between the Sentinel Mountains and the Horlick Mountains make a link between the two probable. The possibility of an ice-filled trough connecting the Ross Ice Shelf and the Filchner Ice Shelf of the Weddell Sea therefore seems less likely than was formerly believed to be the case. It is hoped to solve this question by means of a United States airborne traverse during the 1959–60 season, which will make a series of soundings along the 88° W. meridian.

Another useful technique for obtaining information on continental structure is to study the group velocity of certain earthquake waves, namely Love and Rayleigh waves, which are propagated through the earth's crust. Due to differences in the thickness of the crust, such waves travel more rapidly under the oceans than under the continents. Press and Dewart [16] have shown that these waves travel across much of Antarctica more rapidly than across other continents, and hence conclude that possibly one quarter of the assumed "continental" path is equivalent to "oceanic" conditions (see map). In other words, the earth's crust is thinner over a moderate proportion of the wave path over Antarctica, and may therefore be expected to lie well below sea level. At first sight this appears to fit some of the ice thickness measurements over "West Antarctica". However, some of the wave paths lie entirely across "East Antarctica", which suggests that this region may also prove to be a less extensive continent than this review has so far assumed. Further studies of such results by independent workers are needed but, even if they are confirmed, the possibility that the earth's crust can be thinner for the Antarctic continent than for other regions must not be dismissed. One should, however, point out that crustal thicknesses of normal continental magnitudes have been found by this method between "Wilkes" base and the Victoria Land mountains by both Press and Dewart and by a New Zealand group working on results from Cape Hallett and "Scott Base" at McMurdo Sound.[17]

Measurements of the thickness of ice shelves, particularly by Crary[6] on the Ross Ice Shelf, have confirmed the trend of thought in recent years. They are found to be generally afloat, with thicknesses ranging commonly from some 200–300 m. near the ice front up to almost 1000 m. on the inner parts of the Ross Ice Shelf, although the major part of this ice shelf appears to be between 350 and 600 m. thick.

Further examples have been found of the low rounded ice hills which rest on a base mostly or entirely below sea level, usually adjoining ice shelves. A particularly interesting case is Drygalski Island which is entirely surrounded by sea, but nevertheless, according to Kapitsa,[18] rests on a base which is below sea level.

Mass balance of the Antarctic ice sheet

The first major conclusion based on the dome shaped ice sheet covering "East Antarctica" is that sufficient time has elapsed since the formation of the

ice sheet for it to build up sufficiently for outflow of ice to take place from the centre of the continent. In view of the low rates of accumulation and great ice thicknesses near the central regions, the ice cover must certainly have been building up for at least 20,000 years but the actual age of the ice sheet may be many times greater. Whether or not the total amount of ice stored on the Antarctic continent is increasing or decreasing is not known, and experts differ in their views on this subject. Methods of determining such changes fall into three categories:

(*a*) *Budget methods.* In these the total mass of ice estimated to fall on the continent in one year is balanced against the total loss of ice from the continent by outflow, melting and evaporation.

Recent estimates using this method have been made by Loewe[19] and Lister.[20] The annual net accumulation over the continent is now known to vary from 40 g. per sq.cm. (less than London's rainfall) in coastal areas with heavier snowfalls to 8 g. per sq.cm. or less on the high inland plateau; Lister uses a mean figure for the whole continent of 11 g. per sq.cm. on the basis of the results of the Commonwealth Trans-Antarctic Expedition, which is similar to Loewe's figure. They both find that they are unable to suggest sufficient types of ice wastage to balance much more than half of this accumulation. Measurements of the outflow of ice, such as those by Mellor[21] and Dolgushin,[22] seem inadequate to produce a balanced budget, and hence a tentative conclusion that the Antarctic ice mass is increasing is reached. The mass discharge of the largest ice streams, and the amount of melting of the bottom of the ice shelves, is almost unknown. Wexler,[23] making a reasoned guess at the latter, estimated that the mass budget may well be balanced, but actual measurements are needed before more weight can be given to this view.

(*b*) *Measurements of the changes in ice cover with time.* At present this can only be done around the borders of Antarctica where mountains and nunataks protrude through the ice sheet to provide suitable reference levels. It is relatively easy to identify a recent recession of the ice by means of freshly exposed rock, but much more difficult to distinguish between a constant and a rising ice level, since features such as lichens, when buried, are not as readily identified as in the case of a falling ice surface. Of recent papers on the subject, Shumskiy[24] considers that the ice in the vicinity of Bunger Hills is in retreat, whereas Péwé[25] and Mellor[26] conclude that little change in the extent of the ice is taking place at present in the areas they examined.

All these studies refer to the periphery of Antarctica, and changes in the central regions may not be in step with those around the boundaries. Unfortunately no mountains are available to act as reference levels near the centre of the ice sheet, but, as a long-term project, it has been suggested that repeated and accurate ice depth measurements over selected areas be made to determine whether the thickness is changing in the interior.[27]

(*c*) *Estimates of changes in world-wide sea level which can be attributed to changes of the Antarctic ice sheet.* If, as the budget figures suggest, the mean load of ice on Antarctica is increasing by around 5 g. per sq.cm. per year, one would expect the mean sea level to fall at a rate of over 1 mm. per year.

However observations over the first half of this century suggest that the mean sea level is rising at a rate of 1 or 2 mm. a year.[28] The Antarctic is not the only cause of changes in mean sea level as water stored on other continents and slight changes of sea temperature will also affect sea level. Nevertheless, Antarctica is by far the largest storage mass for frozen water, and the slight rise in sea level does not encourage the belief that the Antarctic ice mass is increasing.

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ANTARCTIC EXPLORATION YESTERDAY AND TODAY

BY SIR RAYMOND PRIESTLEY

[*This paper is an abbreviated version of a lecture delivered at the Scott Polar Research Institute on* 31 *October* 1959.]

On 1 January 1908 I left New Zealand for Antarctica with Ernest Shackleton, in a 220-ton barquentine with auxiliary engines of 40 horse-power. Two years later, on a 750 ton barque—the *Terra Nova*—I left again with Scott on his famous but ill-fated journey during which the South Pole was actually reached. Half a century later I journeyed south again—in just as good company but under vastly different conditions—first in the Royal Yacht *Britannia* with H.R.H. the Duke of Edinburgh and then as the guest of the Americans on their great expedition, Operation "Deep Freeze IV". I am the last survivor of Scott's Northern Party and first I want to give some idea of adventures at that time, for they were both varied and typical of those days, if somewhat extreme, and point well the contrast between then and now.

The *Terra Nova* was a wooden, square-sailed whaler with auxiliary steam. She could, and did, butt away at heavy pack ice, but of course with nothing like the power icebreakers have today; fortunately perhaps for her, for she would have come apart at the seams under the battering a modern ice-breaker inflicts. It took us a whole month to get through the Ross Sea pack ice while the icebreaker *Northwind* made a similar passage through 300 miles of quite heavy pack ice in 3 days. Then we sailed south to lat. 78° S. through open water for, in the midsummer months, the Antarctic weather is not normally severe enough to freeze salt water and the last winter's ice has already been driven north by the spring gales.

We set up Scott's winter quarters at Cape Evans, in McMurdo Sound, on a rocky spit at the foot of Mount Erebus, an active volcano over 13,000 ft. high, up which it was my fortune to lead the second ascent in December of 1912. When we had built a comfortable hut, and had seen the Southern Party start on its first depot journey, we set about the task of finding a home for ourselves. It had been Scott's intention that we should go east to King Edward VII Land, which he had discovered on a previous expedition but on which he had then been unable to land. We made our way past Cape Colbeck but a northerly wind set the pack down against the shore and the *Terra Nova* had to turn and run for fear of being beset. We steamed west again for the Bay of Whales, where Shackleton had two years previously reported low ice cliffs, for we hoped to establish ourselves within reach of land there. To our astonishment, as we rounded the eastern cape of the bay, we saw another ship. Those of us who knew our Arctic history at once recognized the *Fram*; we knew that Scott had a serious rival in the field and returned to McMurdo Sound to tell him what we had found.

We were still without a home. Amundsen was 500 miles east of Scott, so we decided to complete the observational triangle and go 500 miles to the north and so multiply the value of our scientific observations. We settled down at Cape Adare and there, in comparative comfort, we spent the winter of 1911. We did restricted though useful mapping and geological work in the winter and autumn, but in the summer the sea ice left us altogether and confined us to a tiny beach.

In January 1912 the *Terra Nova* returned to pick us up and then our adventures really began. We were landed 250 miles down the coast at Terra Nova Bay, and spent a very pleasant summer doing a geological and topographical survey of the Campbell Glacier and the Priestley Glacier. In the middle of February 1912 we returned to our depot on the coast to wait for the ship. And the *Terra Nova* never came. "Hell's Gate" and "Inexpressible Island", as names on the map we drew next year, afford some dim idea of what happened in the next eight months. We were marooned in summer clothes and with one month's provisions in one of the most inhospitable places along the whole Victoria Land coast; 1912 was destined, in any case, to be the stormiest Antarctic winter yet on record. With us it started to blow a gale in mid-February and we did not have 24 hours calm until the end of September.

I, for one, learned that winter with how little a man can not only live, but be comparatively happy as well. He needs food and drink, in the Antarctic winter he needs shelter and fuel and light as well. Let me tell you shortly how we achieved these few essentials. First of all food: we had with us one month's sledging provisions which I had persuaded Campbell to put ashore because I had been caught out before. We determined we would have a little ordinary food as long as possible, and set aside half of everything, and the whole of the pemmican, not to be touched at all during the winter unless we would otherwise perish of starvation. We knew we could not make our retreat without proper sledging food after the winter was over. The rest we divided up to make it last as long as we could. We had at first two then one biscuit a day as long as they lasted and then we went without. We had twelve lumps of sugar once a week. We had an ounce and a half of chocolate every alternate Wednesday. To drink we had three teaspoonsfull of cocoa in nine pints of water five days a week. On Saturday we had a similar ration of tea. On Sundays the tea leaves were reboiled and on Monday they were dried, served out to the smokers and smoked. For the rest we were to rely on Weddell Seals, but there was no sea ice nearby that year and consequently very few seals. We killed every one we saw and we just got a dozen. They were enough to keep body and soul together but we were hungry all the time.

The next problem was shelter. We could not build a snow igloo because the wind was blowing granite gravel about and would soon have made short work of any such hut. We could not build a hut of stone because the island was of fine-grained granite which weathered by exfoliation into round boulders which we could not pile. There was only one thing we could do; we went to ground like rabbits. There was on the island one snowdrift 7 ft. thick. With

short-handled miner's picks from my geological outfit we hacked out a chamber 12 ft. long by 9 ft. broad by 5 ft. 6 in. high. We lined the bottom half, which was of ice, with snowblocks to improve its insulation and we lived here in the cold and dark from 17 March until 30 September, when we were able to start down the coast. We made lamps out of Oxo tins with string suspended from safety pins for wicks. We cooked on blubber stoves made out of paraffin oil cans, burning the blubber on old dried seal bones. And we survived.

At the end of September the wind dropped, the sun was fairly high and we started down the coast. It was not an easy journey and it lasted 35 days. When we started only four men could pull, one had to ride on the sledge and the sixth could just stagger along beside it. For the first fortnight, until we got out of the gale area and could get fresh seals, we had only two cooked meals a day. At midday we crouched in the lee of the sledge and ate a biscuit and a slice of raw blubber and raw meat. But our troubles were nearly over. For the last three weeks seals were plentiful and we had as much meat as we could eat. A week from home we found a depot of sledging provisions that had been left by another party, and overeating replaced semi-starvation as a hazard to our well-being. On 7 November we arrived at Hut Point.

That is a fair cross-section of exploration 50 years ago. In 1956, in the Royal Yacht *Britannia*, I returned to the Antarctic, this time to the other side, and visited seven of the F.I.D.S. bases in Graham Land. Here, because of the scantiness of our resources, the old, tried methods of dog sledging and man-hauling still prevail, though in 1956 and 1957, Hunting Aerosurveys Ltd., under contract to the Falkland Islands Government, surveyed 50,000 square miles of the Dependencies from the air by means of Canso flying boats and ship-based helicopters.

In December 1958 I sailed to Antarctica again as the guest of the Americans in "Deep Freeze IV". I left New Zealand this time in a 13,00-ton United States naval cargo carrier, in convoy with a tanker and an icebreaker of 8000 tons. In the Antarctic I transferred to the icebreaker *Staten Island* and saw more of the coastline in two months than I had seen in three years 50 years ago. It is a measure of the technological progress that has been made, very dimly foreshadowed by the Arrol Johnston car in which I had my first Antarctic motor rides in 1908 and the caterpillar tractors of Scott, one of which I very nearly accompanied to the bottom of the Ross Sea. It so happened that 1959 was a bad "ice" year. In the American convoys I passed through more pack ice than I had ever seen before. Before the season was out ships—many of them much more powerful than any in use 50 years ago—were in trouble all over the Antarctic seas and both the Americans and, to a lesser extent the Russians, were spending much of their time and effort on rescue work.

It emphasized to me how much we were in the old days the prisoners of our limitations. Standing in calm weather watching a balloon go straight up overhead to 60,000 ft. made me think how our theories of Antarctic weather went awry because the only places where we could reach the coast in our under-engined wooden ships were where the outrushing katabatic gales were strongest and most persistent, keeping the coast clear of sea ice for weeks at

a time. We thought, too, that the Emperor Penguin was on its way out as a species because the only rookery we knew of was at the southern edge of the Ross Sea where furious south-east gales broke up the ice and let us in but where, because of the same gales, the birds could only with difficulty exist. Today we know of a dozen rookeries where the birds live in comparative comfort, and more are found every year as ice-strengthened steel vessels with powerful engines range along the coast.

Another impressive thing about the cruise was the evidence of the scale of the present effort. The United States alone had taken 10,000 men south of the Antarctic Circle in three years. On board *Staten Island* a conference of biologists was called. All the eighteen men present, except Commander Price-Lewis and myself, were specialists in one or other branch of biology or allied sciences —and biology was not one of the main objectives of the International Geophysical Year. When we got ashore I think the thing that astonished me most was the application of the bulldozer to the Antarctic scene. They were everywhere and what they have accomplished requires to be seen to be believed. On a difficult 28 miles of the "Byrd" trail inland from "Little America V" 4,000,000 tons of snow was shovelled into crevasses to make the road good. Our old headquarters at Hut Point was unrecognizable, the landscape had been so pushed about. At Marble Point, where a permanent runway is being surveyed, the camp is aptly named F.U.B.A.R., which being interpreted means "Fouled up beyond all recognition". As I looked round my old haunt Hut Point in McMurdo Sound I thought, rather sadly, that a similar description would have fitted there very well. It remains true that omelettes cannot be made without breaking eggs. Mechanical transport columns are making traverses and gaining knowledge all over the continent, not without danger and death. Ingenious crevasse detectors probe for weak places. Nevertheless, even in spite of all precautions, accidents occur. Williams Air Facility is named after a tractor driver who lost his life in the Ross Sea. We are all familiar now with the sight of Vivian Fuchs' Sno-cats poised across great chasms. While I was in Antarctica a whole tractor train disappeared into the depths of a crevasse on the Ross Ice Shelf, fortunately without loss of life. As I watched the tractor trains crossing the sea ice in McMurdo Sound, where in 1911 I myself followed the first Scott caterpillar through the ice into a chilly sea, I could understand why driving with long reins in remote control was a strictly enforced rule.

The application of air travel to polar exploration is another accomplished fact, in fact today a commonplace. The first plane to land at the South Pole, *Che Sera Sera*, was being dismantled as we arrived to be brought back for housing in the Smithsonian Museum. As we motored in a Pole-cat to join the Auster that was to take us to Marble Point to see tests being made for a 10,000 ft. rock-based runway, we passed Dakotas on the snow airstrip behind McMurdo base. Today survey and geological parties, complete with dog teams and supplies, are landed as a matter of course by aircraft within a few miles of the mountain ranges that are their objective, and are kept supplied at prearranged points as and when required.

At Marble Point itself we landed on a runway from which our Auster raised clouds of rock dust, a phenomenon I never expected to see on Antarctic shores though due, it is true, to an exceptionally long wind-free spell. The wreckage of another Auster, over which we flew on our way in, reminded us that all this had not been accomplished without loss. Two good men had died here, and another discoloured patch 400 miles farther north along the Victoria Land coast testified to another crash this same summer that had cost six lives.

In 50 years of Antarctic exploration much has changed. Most of the discomfort has gone and with it much of the glamour. Antiscorbutics have removed that great bogy scurvy. More adequate transport has doubled the fuel ration, and so taken the sting out of cold weather sledging. No longer will one's sleeping bag double in weight in a few days with ice from breath and sweat. The dangers have changed, but they are still there. Perhaps the most satisfactory feature of the situation today is the international co-operation that is taking place regularly and almost without exception in this outpost of a distracted world where elsewhere suspicion and distrust prevail. In February 1959, in Wilkes Land, I saw a £1 m. worth of gear handed over from one country to another: a well-established base for 17 men. At a short moving ceremony a new set of scientists took over and work continued without pause.

A voyage in an icebreaker is a stimulating affair. As *Staten Island* battered her way along, I saw more of the Antarctic coastline than I had imagined in my most optimistic dreams. I can imagine no more productive means of coastal exploration in Antarctica than to give such a ship a free hand for the whole summer season. In 16 days she had battered her way through 16 miles of solid ice, 6 to 8 ft. thick, in McMurdo Sound. If she, or a sister ship, were freed from ordinary logistic duty, fitted with a laboratory and a complement of scientists (as *Staten Island* indeed was) and let loose along the less accessible Antarctic coasts from October to April, with launch and helicopter as auxiliary aids, she could do more valuable work in that time than any static wintering party could accomplish in a whole year.

MINING IN THE SOVIET ARCTIC

BY TERENCE ARMSTRONG

[*MS. received 5 October 1959. This paper is based on a lecture delivered at the Centre d'Etudes Arctiques, Ecole Pratique des Hautes Etudes, Paris, 11 June 1959.*]

CONTENTS

Ores mined

The major economic benefit which the U.S.S.R. derives from its Arctic territory comes from the exploitation of mineral resources. Detailed information about production has long been withheld, at least in the case of important minerals, but enough general information is available to permit a summary in broad terms of current activity in this field. Murmanskaya Oblast' is not included in the summary, because its relatively mild climate, near absence of permafrost, and favourable location render it atypical of the Soviet Arctic as a whole.

Copper nickel sulphide. The largest and probably the most important metal mining centre is Noril'sk, near the mouth of the Yenisey. Copper nickel sulphide ore is present here in great quantities, yielding nickel, copper, platinum and cobalt. It was the presence of nickel which attracted the initial interest. The area was first investigated geologically in 1925–26, when no nickel was produced in the U.S.S.R. The decision to exploit was taken in 1935, and production started in 1940. By this time other deposits in the U.S.S.R. were also coming into production, in particular a much more accessible one at Orsk in the southern Ural.[1 (p. 157), 2(p. 74–76)] Development at Noril'sk was particularly fast during the Second World War, when not only the nickel but the copper was badly needed (in 1942 copper was so scarce that 70 per cent of the country's needs were met from lend-lease supplies).[2(p. 114)] The town had in 1937 been linked by narrow gauge railway with Dudinka on the Yenisey, a port equally accessible to sea and river shipping. The railway was converted to the normal gauge after the war.[1 (p. 269)] In 1959 the town numbered 108,000 inhabitants,[3] and smelting was carried out there. A settlement of these proportions can only be based on considerable production. The only figure available, however, is for 1947, when nickel output at Noril'sk was estimated to be 3000 metric tons, or 20 per cent of the Soviet total.[2 (p. 76)] Production has undoubtedly increased, but the proportion today may not be much different, for the mine at Orsk has expanded, and the old Finnish mine near Petsamo, acquired in 1944 and now called Nikel', is in full production. Copper is no longer so urgently needed, as a result of developments in Kazakhstan and elsewhere. Cobalt is not in short supply. Only the platinum may

now have a high priority; for although Russia was for long the world's major producer, output fell off sharply between the two wars, and Noril'sk must now be helping to offset the decline.

Gold. Historically, the first mineral to be exploited in the Russian Arctic in significant quantities was gold. Mining in the Lena basin dates back to 1846, but there has been enormous development since the Revolution. The early Arctic workings were placers on the Vitim and Aldan. Later, reefs were also mined. Hydraulic machinery and dredges of the type designed for alluvial mining in Alaska were imported, with notable effects on labour requirements. The Aldan deposits were the richest in the country when they were first exploited, but now the upper Indigirka area is said to be richer,[4(p.17–18)] and consequently production costs are lower there. Output in Yakutskaya A.S.S.R is about 20 per cent of the national total.[5] The other and greater Arctic gold-producing region is the Kolyma basin, farther east. Output there is the subject of speculation, and may be as much as three times that of Yakutskaya A.S.S.R. This would mean that the Arctic provides a good three-quarters of Soviet output, which was stated in a recent article in *The Times*[6] to be between twelve and fifteen million troy ounces in 1958 (second to South Africa, with 17·6 million). The figures for the U.S.S.R., it should be emphasized, are in fact arrived at by inference, but are probably as close to the truth as can be hoped for in the absence of any authoritative statement.

Soviet sources give no figures for production costs, but *The Times* article already referred to suggests that they are five times higher than the selling price of gold in the west. There are many possibilities of error when working from the fragmentary data available, but one may at least agree that they are higher. It must be assumed, therefore, that high costs are acceptable because gold is required to finance vital imports or for other purposes requiring foreign exchange.

Tin. Tin is another major product of the Soviet Arctic. For many years it was a "deficit" metal in the U.S.S.R., and strenuous efforts were made to end dependence on imported supplies. Production was first started in Transbaykal in 1933, and later in Kazakhstan and the Soviet Far East. Then a rich deposit was discovered at Ege-Khaya on the Yana in eastern Siberia, and production started here apparently during the war. There is no doubt that it is now one of the most important industries in this region, and the settlement itself officially ranks as a "town" Other deposits in the same general region were also developed, as well as three farther east, at Orotukan on the Kolyma, Pyrkakay on the north of Chukotka, and, in 1959, at Iul'tin, also in Chukotka. Open-cast mining is possible at many of the deposits, an important factor in controlling costs. The ore undergoes primary concentration on the spot, and is sent to Novosibirsk for further concentration and smelting. Although the contribution of these mines is not known, it is likely that they may between them account for over half of the Soviet total output.

Mica. A significant exploitation, although on a smaller scale than the preceding ones, is that of phlogopite mica, which is used increasingly in the electrical industry as an insulator. There was a good deposit at Slyudyanka

on the shore of Baykal, but this was exhausted in the early 1940's. The onl other deposit in the country is round Tommot on the Aldan, and this wa rapidly exploited during the war to offset diminishing production at Slyudy anka. Output reached 11,200 metric tons of raw mica in 1954, which was ove twice the quantity produced at Slyudyanka 20 years before. Known reserve are sufficient for several decades at 1954 consumption levels.[4 (p. 63–66)]

Diamonds. A development of the most interesting potentiality was th discovery of diamonds in Yakutskaya A.S.S.R. after the Second World War. The U.S.S.R. has hitherto been dependent on imported diamonds, a situatio made the more difficult by the fact that diamonds are on the United States list of prohibited strategic exports. Estimated reserves are sufficient to mee the country's needs for "many years" at a rate of five to ten million carat a year, and even permit export.[4 (p. 44), 8] The preliminary work of constructin roads, air strips and settlements is now in hand. Production from placer started in 1958 at "Mir", where the first kimberlite pipe was discovered This is 80 km. from the nearest settlement, Vilyuchan on the Vilyuy, and i is the most accessible of the promising areas. Ore processing plant is unde construction here, and the settlement of Mirnyy is being built round it.

Coal. Coal is mined at many points, but one should distinguish betwee mines of national importance, and those of purely local significance. Th latter are quite numerous, because the remoteness of Arctic settlement makes it worthwhile to exploit any local fuel source, even if the quality i very poor; but they do not merit consideration here. There are. however two developments of national significance.

The most important is the Pechora coalfield, which was first exploited jus before the Second World War. It became important only when the railwa linking it with the rest of the country was completed in 1942, and productio increased rapidly to four million metric tons a year by the end of the war During those years the coal was needed to help replace output from overru areas, but this need disappeared relatively soon, and the coal was then use to supply Leningrad and other northern centres, as originally intended Expansion has continued. The latest production figure is sixteen millio metric tons in 1957.[9] Vorkuta, the chief mining centre, has 55,000 inhabitants. The coal is bituminous coking coal, comparable in quality to grades PZh and K from the Donbass.[2 (p. 192–94)] There is a shortage of such coal in the north o European Russia, the Donbass being the only other producer.

The other development is still in the planning stage. Large reserves of iro ore and coking coal have been found within 100 km. of each other round Chul'man in the basin of the Aldan. It is proposed to exploit these deposits known as the south Yakut coalfield, as a secondary basis for industry in th Far Eastern provinces of the U.S.S.R. Other sources of coal, and to a lesse extent of iron ore, are known in more accessible parts of the Soviet Far East but preliminary calculations suggest that production in the Chul'man are would be cheaper.[4 (p. 67–93)]

Oil. Finally, there is one nationally important oil-producing area, th Ukhta region in the Pechora basin. The presence of oil here has been know

since the time of Peter the Great. Sporadic attempts were made to obtain it, but significant quantities were produced only after 1935. The emergencies of the Second World War caused output to rise to 1,200,000 metric tons a year, but it was estimated to have been reduced to 800,000 metric tons in 1950,[10] or about 2 per cent of the national total. The emphasis has now shifted to natural gas production, which reached about 10 per cent of the national total in 1958,[11] or 3000 million cubic metres. The seven-year plan (1959–65) envisages piping this gas to the Ural industrial region.

Factors affecting production

The other main point to be considered in this paper is how exploitation is carried out, with special reference to the particular difficulties imposed by the environment.

Transport. The lack of a transport network is obviously the fundamental difficulty. The river system has been used since earliest times, and it still provides the best solution. Its disadvantages, apart from the ice, are the shallow depth of many stretches of river, and the variations in water-level during the summer. Recent figures for river transport in the Lena basin indicate its continuing growth. In 1956 a fleet of 170 powered vessels and nearly 500 barges transported over a million tons of freight, or more than twice the 1940 figure.[4 (p. 355, 362)] The capital expenditure involved, although significant, is small compared to that required for roads or railways, for the cost of construction of an all-weather road in flat terrain in Yakutskaya A.S.S.R. averages 250,000–300,000 roubles per km., and a railway ten times as much.[4 (p. 412, 416)] But the rivers are open to navigation for less than half the year, and in winter traffic must be transferred to the roads. These are mainly *avtozimniki*, tracks which have a surface solid enough to take traffic only in winter. Formerly the *avtozimniki* were often on the river ice, but now they are more frequently overland. This alternation between road and river has long been used, with difficult periods (*rasputitsa*) in spring and autumn when travel is impossible. Pack or draught animals, for instance reindeer, are also widely used when neither river nor road is present. There is a remarkable difference in costs between river transport on the Lena and motor transport in Yakutskaya A.S.S.R., the latter being more expensive by a factor of sixteen; however, if the comparison is with one of the less accessible rivers, such as the Yana, the difference drops to a factor of two and a half.[4 (p. 389)] Both methods are still far from having reached the stage of smooth and regular operation, and deliveries are often delayed, sometimes for many months. Hence, of course, the incentive to develop air transport, which is now recognized as being the most economic way of transporting personnel and other light freight in remote areas. Railways, with the exception of the Pechora line, play very little part. Planning on a spur of the Trans-Siberian line running to Yakutsk, Magadan, and Bering Strait was not unnaturally abandoned in 1948 before construction started; but a line to Chul'man would be necessary if mining plans there are realized,[4 (p. 416–18)] The transport network

as a whole, then, can be described as serviceable, but no more than that. Furthermore, whenever industrial development takes place in a new region, this necessitates far-reaching improvement of the existing network before the extra traffic can be handled.

Labour. The population of Yakutskaya A.S.S.R. was 489,000 in January 1959, and the density was 0·16 per sq.km.[3] This very low figure is typical of the Soviet Arctic. Labour has been attracted in two ways. First, by straightforward compulsion. Many undertakings owe their existence to convict labour, but it seems to have diminished in the last five years. The other method is the attraction of high wages and other privileges. The law provides[12] that all workers in the "far north", which includes the sub-Arctic down to the latitude of the Trans-Siberian railway in places, receive a bonus and special pension and vacation privileges (the bonus not being subject to deductions for underfulfilment of the norm—a substantial advantage).[13] They are thus not less than twice as well off as they would be in a normal area. These attractions are successful, but it is admitted[4 (p. 422)] that living conditions are not yet such as to offset the worker's desire to leave as soon as he has earned the money he wants. The population is therefore temporary, with an abnormally high proportion of men of working age. The State seeks to rectify this unstable situation by such measures as increasing the numbers of nurseries and kindergartens, in order to give women the incentive to come and work. Use is also made of native labour, but the native peoples are not strong enough numerically to have any substantial effect on the labour problem. The solution of that problem, however, in spite of the successful measures just mentioned, remains incomplete, for many undertakings are still below strength.

It is clear that the degree of success achieved depends largely on social factors specially valid in the U.S.S.R., such as social discipline, and laws relating to unauthorized mobility of labour. This is so even if convict labour is left out of account. The attraction of 108,000 people to Noril'sk in some 25 years seems to have been accomplished by a nice blend of compulsion (in the early stages) and appeal to patriotism (evident in the Soviet press a few years ago). Here it is probable that the social and cultural amenities are beginning to be enough, if not to attract, at least not to repel newcomers. An indication of the growing importance of Noril'sk as an administrative and cultural centre is the fact that the Research Institute of Agriculture of the Far North [Nauchno-Issledovatel'skiy Institut Sel'skogo Khozyaystva Kraynego Severa], an institution of national significance, moved there from Leningrad in 1957.

Electricity. All the mines are much too remote to be accessible to any regional grid, and power must be made locally. Water power resources abound, but uneven water flow, presence of permafrost, and (less important) ice crystals in the water, create difficulties which have not been wholly solved. Thermal stations, almost all of less than 500 kW., are therefore the rule, and the problem becomes one of fuel sources. At the moment timber is the most easily accessible fuel, and is the most widely used; in 1953, 56 per cent of power stations in Yakutskaya A.S.S.R. used it. A widening circle of devasta-

tion surrounds the stations, and in one case (Batygay) timber was being cut 300 km. away.[4 (p. 164)] This calls for a large labour force, which would be far more effective if employed in mining coal. As a result, generation of electricity in Yakutskaya A.S.S.R. is very expensive. The diamond mining on the Vilyuy, however, is stimulating the first attempt to build a hydro-electric station on permafrost.

Supplies. The Russians have calculated that to produce one ton of tin in the upper Yana region, 30 to 35 tons of assorted supplies are necessary, while for one ton of gold in the Aldan region the figure is "several thousand" tons.[4 (p. 20)] The way in which this demand is to be met is one of the factors governing the initial decision as to whether a given deposit is going to be worth exploiting. One of the results of this need in remote areas has been the building up of local secondary industries at such centres as Noril'sk and Yakutsk. The point of greatest interest is where the line is drawn between goods it is cheaper to bring in from outside, and goods it is cheaper to manufacture on the spot. The Soviet policy, as far as can be discerned, is to encourage local production, even if it is not always economic, because it is an important factor in improving living conditions and therefore in attracting labour. For instance, there is a boot factory employing 153 workers at Yakutsk, and a sausage factory employing 71.[4 (p. 298)]

Permafrost. The most fundamental physical difficulty encountered is the existence of permafrost. The balance of the permanently frozen layer is upset by any interference, such as the placing of a load on the surface, or cutting into it and laying it bare—that is to say, by any construction work. The Russians have long been developing empirical methods of minimizing the practical effects of such disturbance, and since about 1930 have been interested in the theoretical approach also (with the creation of the institution which later became the V. A. Obruchev Institute of Permafrost Studies [Institut Merzlotovedeniya imeni V. A. Obrucheva], now the major centre in the world for such work). The stage has not yet been reached at which any type of building can be successfully erected wherever it is wanted, but photographs of Noril'sk show that great advances have been made. This problem is probably no longer a major obstacle in the setting up of an industrial enterprise in the Arctic.

Conclusion

The Russians are grappling successfully with the very difficult conditions, and can turn distant assets to advantage. The data are too scanty to determine the degree to which they are successful, but the scale of the various undertakings suggests a large mineral output. The pattern of development appears to be controlled mainly by straightforward economic principles: that is to say, resources are exploited only if they are exceptionally rich or rare, because only then can the increased costs of production be recovered. Regional self-sufficiency is a declared national objective,[14] but there is little confirmation that this factor, or other more directly strategic considerations, have played much part in this aspect of Arctic development. Only Noril'sk perhaps

provides an example, for there the rarity value of the minerals has decreas since the war, and yet the town has become the largest in northern Siberia. Co parison of the operation of Soviet Arctic undertakings with industrial practi and experience in the west leads to the conclusion that, in certain respec the Soviet social and economic system has conferred decided advantages; f instance, in the provision of labour; in the integration of research wi industrial needs, as exemplified by the study of permafrost; in the overa planning, which seeks to ensure that complementary phases of the sam operation advance at the same speed—that transport facilities, for instanc keep pace with the demands of a mining concern; and finally, in capital i vestment. It has recently been written of mining in Arctic Canada: "For t actual exploitation of ores in northern areas it is clear that immense capit outlay is required for railways, ports and towns and that only the large companies are capable of obtaining it."[15] In the U.S.S.R. this limitation avoided.

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UNITED STATES AIR-DROP OPERATIONS IN ANTARCTICA, 1956–59[1]

BY JOHN TUCK JR.

[*MS. received 24 October 1959*]

CONTENTS

Introduction

The establishment of the United States IGY stations at the South Pole and in Marie Byrd Land, with their subsequent annual re-supply, has involved the delivery of men and matériel by air on a scale previously unknown to Antarctic operations. "Amundsen–Scott" station at the South Pole was planned and executed entirely by air, with C-124 Globemasters of the United States Air Force air-dropping the great bulk of the required cargo tonnage, and Navy ski-equipped R4D and P2V aircraft delivering personnel and non-drop cargo. In the case of "Byrd" station, the bulk of the cargo was planned for delivery from "Little America V" by tractor train, assisted by ski-equipped aircraft carrying personnel and some cargo to the station, and giving logistic support to the tractor trains. A considerable amount of matériel was also air-dropped by the C-124's, both cargo for the station and fuel for the tractor trains. In addition, a small amount of cargo was air-dropped for the setting up of the small summer station on the South Pole route (formerly "Liv Camp", now the "Naval Auxiliary Air Facility, Beardmore Glacier").

"Little America V" was closed in January 1959 and, except for one tractor train in 1960, the entire "Byrd" station resupply devolves upon the aircraft operating from McMurdo Sound.

"N.A.F. McMurdo"

The "Naval Air Facility",[2] McMurdo Sound, was built during "Deep Freeze I", 1955–56, and serves as the Antarctic operating base for heavy wheeled aircraft. These are mainly the 90-ton Globemasters of the 53rd Troop Carrier Squadron, eight to ten of which fly to the Antarctic from New Zealand

[1] In this article, examples are drawn primarily from the "Deep Freeze II" operations at the South Pole station, with which the author had personal contact. Opinions expressed are his own.

[2] Formerly "Williams Air Operation Facility".

every summer. There is frequent rotation of aircraft between McMurdo and New Zealand, and there are usually four on the ice at a time.

Among the facilities provided by "N.A.F. McMurdo" are those for the berthing and messing of air crews and support personnel, the handling and rigging of drop cargo, the storage and handling of aviation fuel, communications, radar and homing equipment, and a limited maintenance and repair potential. The runway itself, on the bay ice, is equipped with ground controlled approach gear, air control tower, and ancillary runway facilities. The deterioration of the runway surface during the height of the summer, and the possibility of the bay ice breaking out, has led to scheduling wheeled aircraft operations between about 1 October and mid-December. During "Deep Freeze II", the first C-124 arrived at "N.A.F. McMurdo" on 20 October 1956 and the first drop in the area of the South Pole was made on the 26th, over three weeks prior to the arrival of the Advance Construction Party. The drop, of 24 barrels of diesel fuel, was never located. Full-scale drop operations began after the landing of the Advance Party at the South Pole on 20 November, by two Navy R4D's. They continued until mid-December, when depleting stocks of aviation fuel at "N.A.F. McMurdo" and the rapid deterioration of the runway surface, forced suspension of wheeled aircraft operations, and the planes returned to New Zealand. Repairs to the runway were carried out under the supervision of Dr Andrew Assur of SIPRE, and with these and later colder temperatures, Globemaster operations were able to be resumed on 9 February 1957, and the drop missions to the South Pole and "Byrd" stations completed.

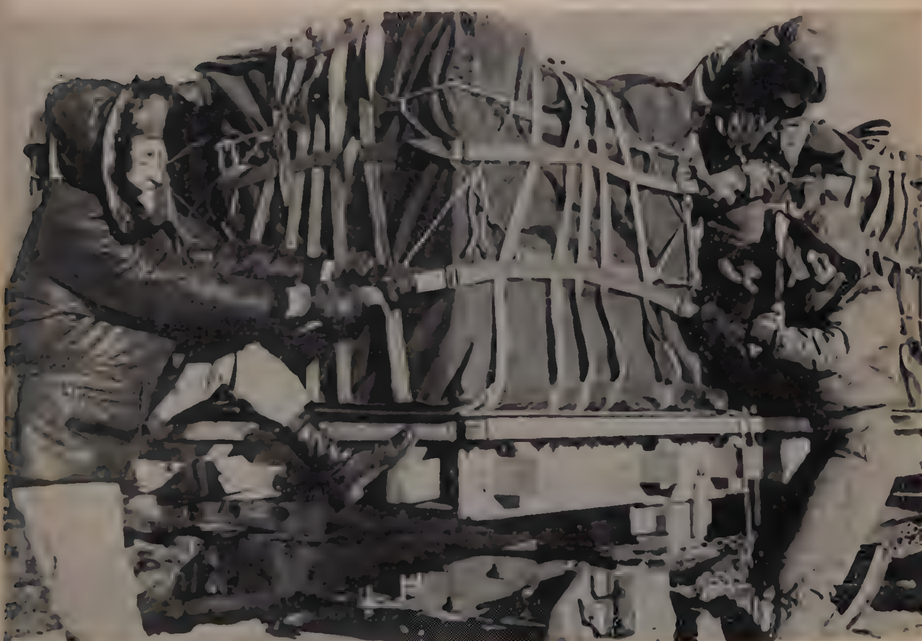
The following season, the first Globemaster arrived at "N.A.F. McMurdo" on 4 October 1957. Air drops were begun on the 17th, and ended on 4 December. Five missions were scheduled for February 1958, but were not carried out due to the late arrival of the C-124's at "N.A.F. McMurdo", and the breakout of the bay ice, which carried most of the runway out to sea.

During "Deep Freeze IV", 1958–59, the Globemasters began to arrive at "N.A.F. McMurdo" on 4 October 1958, drop missions began on the 8th, and were completed on 12 November. During "Deep Freeze 60" drop missions took place between 16 October and 12 November 1959. Such early completion of the air-drop programme, highly desirable operationally, entails the shipment to "N.A.F. McMurdo" of the bulk of the South Pole and "Byrd" station cargo during the preceding season. Supplementary items can be flown in from New Zealand; during "Deep Freeze 60", for example, a total of 446 tons of cargo were airlifted to "N.A.F. MacMurdo".

The following summary shows the size and scope of air-drop operations during Operations "Deep Freeze II, III, IV and 60":

	Net tons air-dropped			
	South Pole station	"Byrd" station	Other	Total
"Deep Freeze II"	650	209	23	882
"Deep Freeze III"	271	428	15	714
"Deep Freeze IV"	410	478	—	888
"Deep Freeze 60"	538	769	24	1331

Connecting parachutes to four-barrel harnesses of POL in aircraft

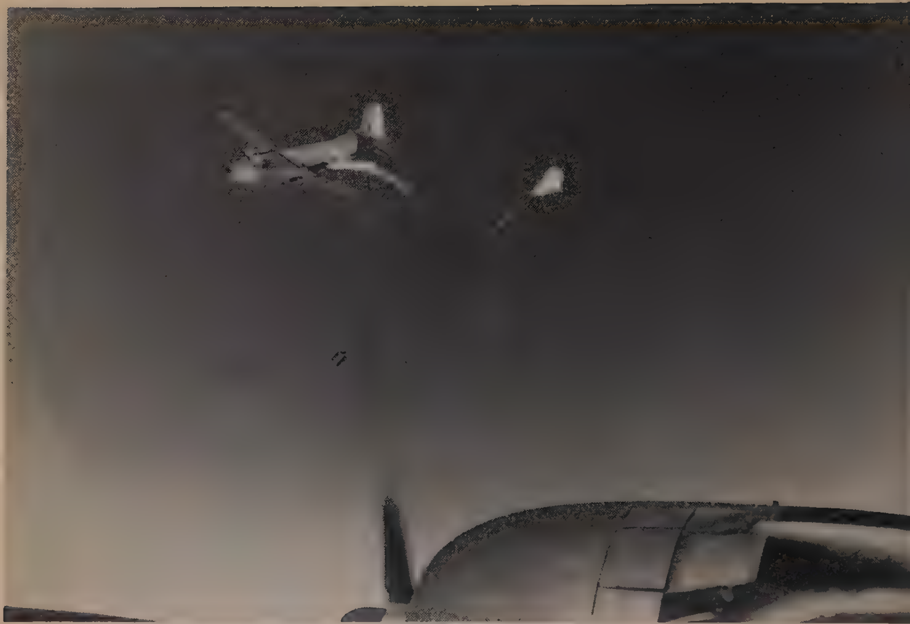


Strapping up an A-22 drop container. Preparing materiel at "N.A.F. McMurdo" for air-dropping by U.S.A.F. Globemaster aircraft

United States air-drop operations in Antarctica, 1956–59

Official U.S. Air Force photographs

(Facing p. 24)



Tractor just after leaving aircraft. One pair of 100 ft. parachutes are about to inflate, the second pair are still deploying from the aircraft

Tractor after landing safely. The tracks seen are from the recovery of earlier drops.
Air-drop of a 7-ton D-2 Caterpillar tractor at the South Pole station

Official U.S. Air Force photographs

	Drop sorties flown			
	South Pole	"Byrd"	Other	Total
"Deep Freeze II"	64	18	2	84
"Deep Freeze III"	22	32	1	55
"Deep Freeze IV"	30	33	—	63
"Deep Freeze 60"	41	56	2	99
	Average net tons per sortie			
"Deep Freeze II"	10·2	11·6		
"Deep Freeze III"	12·3	13·4		
"Deep Freeze IV"	13·7	14·5		
"Deep Freeze 60"	13·1	13·8		

Cargo preparation

The construction material and first year's supplies for the South Pole station were packed and rigged for drop at "N.A.F. McMurdo"; the same was true of the cargo air-dropped at "Byrd" station and to the tractor trains. Subsequently, many items have been pre-packed for air-drop, some being actually rigged in New Zealand, others at McMurdo Sound. This work is carried out by personnel of U.S.A.F. Aerial Port Squadron.

The C-124 drops cargo through a well in the belly of the aircraft, which limits the size of material that can be dropped to 144 in. long, 80 in. wide, and 106 in. high. This necessitated cutting all floor and roof trusses for the South Pole station buildings into two, and making splice plates for their reassembly. A few over-length items which did not lend themselves to being cut and spliced were delivered by ski-equipped aircraft. These maximum dimensions, however, still permit the dropping of such substantial items as D-4 Caterpillar tractors (with bulldozer blade, trunnions and low ground pressure tracks removed), and Weasels (with pontoons removed). These, and other heavy machinery and cargo, are dropped on metal platforms, which are carried in the drop well of the aircraft. The 4 ft. by 8 ft. building panels were dropped in bundles of ten, in a special harness to which the parachute is attached. General cargo is most frequently packed in felt-lined canvas A-22 drop containers, each of about 64 cu.ft. capacity, with some items being crated in 64 cu.ft. boxes which are dropped in a harness. Light, small loads can be dropped in any of several small canvas containers, or by special slings.

Cargo in the above categories is delivered by standard parachute drop, utilizing parachutes of 24 ft., 64 ft. and 100 ft. diameters, which have load capacities of 300 lb., 2200 lb. and 3500 lb. respectively. The 24 ft. parachute is used for the small containers, the 64 ft. primarily with the A-22 container, and the 100 ft. (costing about $1200) with the metal drop platforms. Up to five 100 ft. parachutes may be used for heavy items, such as the 9-ton D-4 tractor. As it has not been feasible to airlift the parachutes out from the South Pole by R4D or P2V, because of load limitations, they have been used but once, making the operation a costly one.

POL (petroleum, oil, and lubricants), in 55-gallon drums, was first delivered using the metal drop platforms, 24 barrels to a platform, with two or three 100 ft. parachutes attached. This method was abandoned, largely because of

the high percentage of failures, and four barrel harnesses were dropped on 64 ft. parachutes. A trial free-drop of six barrels of diesel fuel had resulted in four of the six rupturing, so no further attempts were made to free-drop POL. Somewhat later, stabilized free fall of fuel was tried, and as it proved successful this method was adopted for all POL drops. For this method, a small "ribbon" parachute is used, which slightly slows the rate of descent and ensures that the cargo will land upright. These are attached to four-barrel harnesses, with padding on the bottom and, though the barrels land fairly hard and generally nearly bury themselves in the snow, there is seldom any damage.

The free-drop method has been used primarily for lumber, which is dropped from a low altitude in bundles strapped together with metal bands. Upon impact, the bands break and the lumber scatters. Although there is some breakage, the loss is small and more than made up for by the saving in drop equipment.

During the early drop operations at the South Pole, "quick-disconnects" were used, which were designed to release the parachute when the bundle landed, and thus prevent its being dragged by the wind. These did not prove reliable, however, frequently not operating at all and occasionally doing so in mid-air, so their use was discontinued.

Drop zone layout

At the South Pole station, the drop zone is to the grid south[1] of the base, with the drop "T", a target of fluorescent cloth, placed about 500 yd. south of the camp. The ski runway, oriented approximately grid north-south, with its mid-point roughly 500 yd. to the grid west of the station, serves as a timing point for the aircraft on their drop runs, normally made from grid west to east. Drops seldom land much short of the "T", but they have been known to land a considerable distance beyond. Trail flags, set out at known distances from the "T", have been used as range markers to aid in the location of streamers or free-falls,[2] and to assist the ground drop controller in more accurately advising the aircraft of where the drops land.

Ground control

During the major part of the construction period, November to December 1956, an experienced Air Force drop controller was at the South Pole station; subsequently, this function was fulfilled by the Military Leader. Radio communication with the aircraft was at first maintained with either a hand, battery-powered, V.H.F. transceiver, or with the normal station high-frequency radio, and later by means of an aircraft type V.H.F. transmitter set up in the visual observation dome of the aurora tower. Use of the aurora tower, begun in October 1957, offered the great advantages of protection from wind and

[1] As all true directions at the geographic South Pole are north, the grid system of directions is used. Grid north is in the direction of the 0° meridian: grid south 180°; grid east 90° east; and grid west 90° west.

[2] See p. 28.

cold, and a 25 ft. height-of-eye, giving much greater perspective over the drop zone and its environs. It was also equipped with a separate radio for communication with the station Weasel.

The primary functions of the drop controller are keeping a record of the drops, noting the location of streamers and free-falls, which might otherwise become lost, and informing the pilot of drop accuracy and any malfunctions. He can also give a "negative drop" order if the aircraft is manifestly off the mark, or if ground personnel are not ready to receive a drop. Decisions with regard to the course, speed and altitude of the aircraft, and the timing of drops, are the responsibility of the aircraft commander.

Drop procedure

The number of aircraft dropping during a 24-hour period ranged as high as four at the South Pole station, though three was the normal maximum. Because of the limited number of personnel and amount of equipment available to handle the incoming matériel, present Task Force recommendations are for a maximum of two aircraft a day at the South Pole and three at "Byrd" station.

A flight advisory message is usually received prior to the departure of aircraft from "N.A.F. McMurdo", and communication with the aircraft established well before arrival. The aircraft are equipped with radar, and the stations have homing equipment, though that at the South Pole station was not always reliable; however, aircraft seldom have any real difficulty in locating the station.

Drop runs are normally made from grid west to east, parallel with the line of buildings, and slightly downwind from them. With the prevailing wind at the South Pole being from the grid north-east quadrant, the drops are therefore being made somewhat cross-wind. The drop altitude varies from about 1500 to 2000 ft., hence drops may drift well to the downwind side of the drop zone.

After the discontinuance of the use of "quick-disconnects", whenever the surface wind was sufficient to cause dragging (i.e. over 10 knots), the Weasel was stationed downwind from the drop zone with a crew who chased the drops as soon as they landed, and cut the parachute risers. This method proved quite satisfactory. Only one known drop got away, and that because the Weasel was temporarily out of commission and the "negative drop" was not given. It was later recovered 25 miles away. At "Byrd" station, where winds are considerably higher than at the South Pole, the problem has been more acute, and reports cite cargo recovered as much as 94 miles away, while a number of drops were completely lost.

The number of bundles dropped each pass varied from one to ten or more, mainly according to the type of cargo. Four bundles appeared to be the most satisfactory number to prevent too great spread on the ground, and to facilitate the task of the Weasel crew when there was a dragging wind. Upon completion of a drop run, the aircraft circles while the next group of bundles is being

prepared for release. When two or more aircraft are overhead at the same time they may alternate on drop runs. After each pass, the ground controller informs the aircraft of the results.

Drop accuracy varied from excellent to highly disappointing. Wind, particularly when a parachute is carrying less than its rated load, and occasional delays in releasing cargo, were the main causes of inaccuracy. A high degree of accuracy was, however, common.

Recovery

At the South Pole station, recovery of drop cargo is effected by Weasel and D-2 tractor; "Byrd" station has in addition D-8's and Sno-Cats. At the South Pole, the 9200 ft. altitude causes a reduction in vehicle engine power, but the Weasel is still capable of hauling in one or two loaded A-22 containers, and the D-2 much heavier loads. After cutting the parachute loose from an A-22 container, the shackle to which it was attached can be hooked directly to the Weasel, and the D-2 can hitch on to fuel harnesses in the same manner. Small items are hauled in by sled, as is free-fall lumber. The only drops which the D-2 could not drag in were the 24-barrel platforms of fuel, weighing about 6 tons, which had to be broken down into two loads.

Cargo which has streamed in or free-fallen (other than the intentionally free-dropped lumber) must first be dug out, either by hand or by tractor, the latter method being preferred for obvious reasons. Then, if the container is not too badly disrupted, it can be dragged out of the hole and on into the station, otherwise it must be unloaded piecemeal and put on a sled.

Malfunctions

Of the various types of malfunction which may be encountered in parachute drops, two are of particular concern to the recipients of the cargo: streamers and free-falls. In the former case, the parachute deploys, but the canopy does not inflate. Instead, it simply streams behind the load. The drag of the uninflated canopy slows the descent slightly, but the load lands very hard and sinks several feet into the snow. The extent of damage depends upon the type of material and how it is packed; many durable items will be wholly or partly salvageable, fragile material will almost certainly be damaged beyond use or repair.

Free-falls occur when the parachute does not deploy, when the load tears loose from the parachute upon opening of the canopy, or when individual items break free from a container.

Damage varies according to the nature of the material and its attitude at impact. Bundles of building panels which free-fell but landed on end were recovered with relatively minor damage, others which landed flat were badly smashed, with perhaps only four of the ten panels being repairable. The most spectacular free-fall was a D-2 tractor which tore loose from its rigging, plummeted about 2000 ft., and buried itself over 30 ft. in the snow, a total loss.

Other malfunctions include canopies which tear or blow a panel, and "Mae Wests", the latter occurring when some of the shroud lines pass over the top of the canopy, giving it when inflated the distinctive shape which evoked the name. In both cases the rate of descent is faster than normal, but well-packed cargo generally suffers little or no damage.

The Air Force's figures for the results of the "Deep Freeze II" air drops are as follows:

Type of delivery	Net tons	Percentage recovered
Stabilized free fall	184	97
A-22 container, 64 ft. parachute	306	95
Metal drop platform	246	89
Special slings	82	91
Free fall [lumber]	64	98
	882 tons	94

The last column represents all material which could be used after recovery, including that salvaged from stream-ins and free-falls. During the February 1957 drops at the South Pole, just over 13 per cent of the total number of individual drops were streamers or free-falls. The number of malfunctions during these operations was less than had been generally expected, and most of the items so lost could be replaced.

During "Deep Freeze 60" the U.S.A.F. plans to make use of C-130 Hercules aircraft, a four-engine prop-jet aircraft with a cargo-carrying capacity similar to that of the Globemaster. If these prove suitable for the landing of cargo at the South Pole and "Byrd" stations, a great saving will be effected through the elimination of drop rigging, parachutes, and lost or damaged matériel.

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THE AMERY ICE SHELF AND ITS HINTERLAND

BY MALCOLM MELLOR* AND GRAEME McKINNON†

[*MS. received* 14 *July* 1959.]

During the thirty years since the Amery Ice Shelf was first sighted ther
has been a steady accumulation of information, first on the ice shelf itself an
later on the interesting mountains and glacier systems which lie to its south
The ice shelf occupies the head of a large embayment consisting of Prydz Ba
and Mackenzie Bay, which deeply indents the coastline of the Antarcti
mainland near the borders of MacRobertson Land and Princess Elizabet
Land. An associated valley runs south from the bay, between the Princ
Charles Mountains and the Mawson Escarpment, and it is occupied by on
of the world's largest valley glaciers, the Lambert Glacier. (In fact, recen
findings by Soviet parties suggest that the Lambert Glacier is considerabl
longer than the Beardmore Glacier.[1]) The exploration, survey and subsequen
mapping of the ice shelf, and the mountains and glaciers of its hinterland, b
Australian National Antarctic Research Expeditions in recent years has bee
a major contribution to Antarctic geography.

The land boundaries of the floating ice shelf are well defined by the stee
slopes of the surrounding continental ice and by the occasional nunataks an
mountains which break through the ice. On the western side continental ic
flows steeply down to the ice shelf, forming hummocks and crevasses as i
conforms to the subglacial relief. A number of ice streams push out into th
ice shelf, flow lines showing up clearly on their wind-swept surfaces, an
pressure rolls are formed on the surface of the ice shelf. The floating ice abut
the Prince Charles Mountains in the south-west, and, farther south, th
largest ice streams move down into the ice shelf. In this area it is more difficul
to distinguish between glacier and ice shelf, but a radar altimeter profil
along the Lambert Glacier showed a clear discontinuity about lat. 71° 30′ S
where the slope of the glacier changes to the uniform elevation of the floatin
ice. In the area where the Lambert Glacier becomes afloat the ice surface i
still scored by katabatic winds, and the ice forms the huge "hump and valley
mosaic so common on large, floating glacier tongues. Further north the har
snow-free continental ice becomes buried by snow accumulation. On th
eastern side of the ice shelf several groups of nunataks lie along the edge o
the floating ice and more ice streams flow into the ice shelf. At the borders o
the ice shelf it is sometimes possible to discern a wide fissure following th

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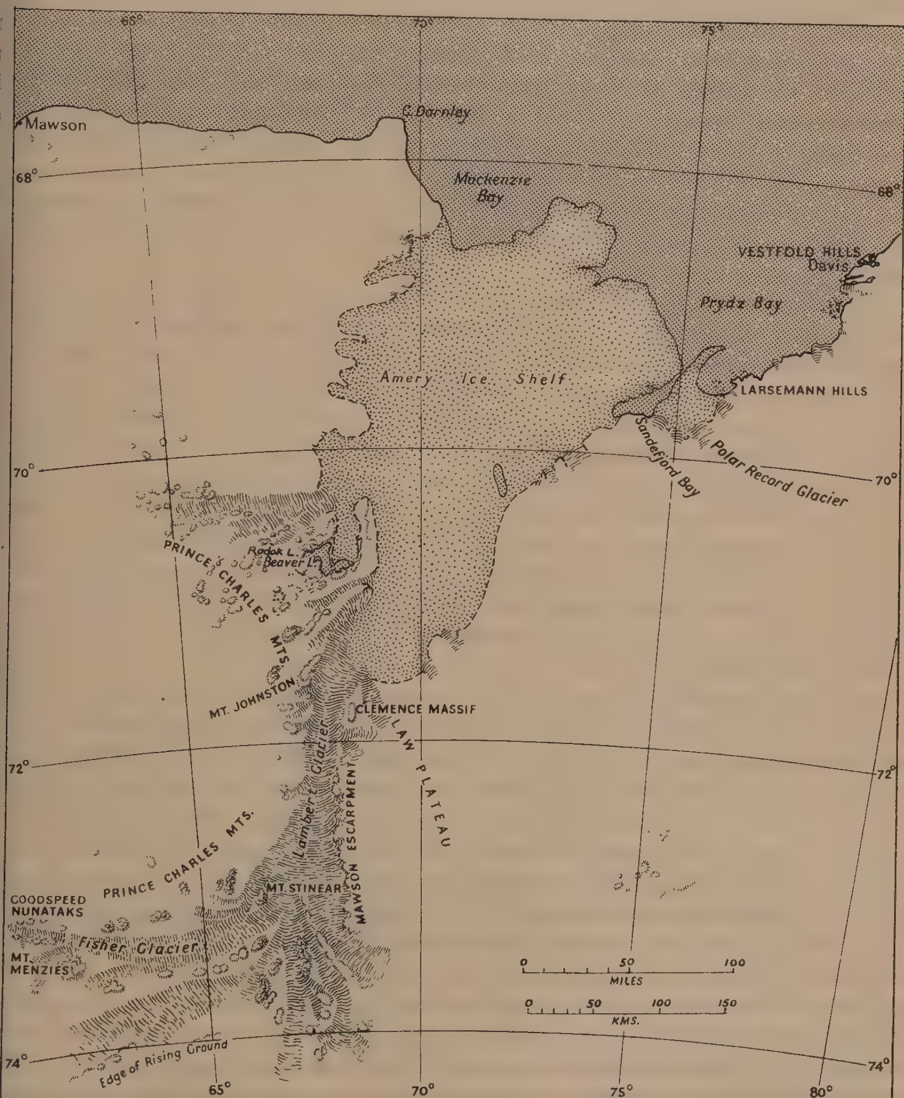
coastline, but in other places there are no signs of relative movement visible from the air. In one area very large parallel cracks or crevasses, presumably due to tidal shear forces, mark the boundary between floating and land-based ice. The major ice streams seem to hinge rather than shear with tidal motion.

Immediately to the east of the Amery Ice Shelf, and separated from it only by Sandefjord Bay, the big Polar Record Glacier and several other ice streams thrust out floating tongues from a section of coastline only about 50 km.



The Amery Ice Shelf, MacRobertson Land.

long. Over an area of about 2000 sq.km. there is a confused accumulation of glacier tongues and trapped icebergs, the whole being cemented together by old bay ice and snow. There is insufficient snow completely to cover the ice and produce an unbroken level surface, but it seems reasonable to regard this area as something intermediate between glacier tongues and ice shelf.

The Amery Ice Shelf differs from most other ice shelves that have been described and one of the most striking features is the great scale of the melting which takes place on the slopes surrounding the ice shelf. Summer melting is sufficiently intense for big surface river systems to be developed over wide areas, and melt streams occur on the Lambert Glacier 450 km. from the sea, at 900 m. elevation. At the southern end of the Mawson Escarpment, also, stone polygons show that the old moraine is not permanently frozen. The ice shelf itself is permanently snow covered over most of its area but Law, in 1956, photographed melt water pools in the hollows between the pressure rolls on the shelf west of the tongue of the Polar Record Glacier. In addition, the banding of icebergs off the shelf suggests the existence of summer melt layers.

Melt water lakes are common, both on the ice and in rock bowls, but no investigation of their formation and behaviour has yet been made. It seems possible that water may remain in a liquid state indefinitely beneath the ice surface of lakes contained in rock bowls. This idea was formed after seeing an apparently floating glacier tongue projection about 1 km. out into Radok Lake in the Prince Charles Mountains and, on applying a theory developed by Werenskiold,[2] it was found that the bed of the lake could be unfrozen for 2½ km. of its 3 km. width. If this is true it would imply a heat flux into the lake from beneath, with heat loss from the surface limited by the ice layer there. It might be mentioned that "Wilkes" station is supplied throughout the year with fresh water from a nearby lake, and the "ice doline" formations described later suggest that englacial water may persist in a liquid state during the winter.

A particularly interesting feature is Beaver Lake, in lat. 70° 47′ S., long. 68° 20′ E. This is not a true melt lake, as was at first thought, for the freshwater ice which forms its surface rises and falls with the tides. Observations made by surveyors both in 1957 and 1958 showed the tidal movement, and tide cracks were traced in 1957 by one of the authors. In 1958 I. McLeod found shrimp-like creatures swimming in the tide crack. The head of the narrow rock-bounded inlet occupied by Beaver Lake is free from glacial ice, as the side flow from the glacier into the mouth of the inlet is not sufficiently rapid to keep pace with ablation; thus the tongue of continental ice terminates whilst still 8 km. from the head of the inlet. Each summer large quantities of melt water flow on to the surface of Beaver Lake from the higher Radok Lake, from the melting ice tongue, and from surrounding hillsides, but some of this incoming water must drain away through the open tide cracks. It is doubtful whether the sea can melt much of the underside of the continental ice flowing into Beaver Lake, since blocks of ice, which have

broken from the tongue and overturned, still contain thick bands of basal moraine.

Around the southern edge of the ice shelf a number of large, steep depressions in the glacier ice have been photographed. These appear to be larger versions of the depressions seen in George VI Sound in Graham Land and variously described as "ice calderas", "craters", and "ice volcanoes". After a discussion between Dr F. Loewe and one of the authors, the name "ice doline" was chosen as a more suitable term and this has been proposed as an addition to ice nomenclature.* The vertical air photograph illustrated† is of an "ice doline" taken from 3200 m. It shows an oval-shaped depression, 3 km. long by 1·3 km. wide, and parallax bar measurements on stereo pairs give the depth as 80 m. below the surface of the surrounding ice. The "ice dolines" seen in George VI Sound by the British Graham Land Expedition 1934–37 were described by Fleming[3] and Stephenson.[4] Fleming offers no explanation of their mode of formation, but Stephenson says: "It looked as if there had been an enormous hollow dome which had suddenly collapsed. . . ." "Ice dolines" were again seen in this area during "Operation Highjump" in 1947 and Byrd[5] surmised that the craters might have been formed by the explosion of gas trapped in the ice. Loewe (private discussion, also in Wegener[6]) tells of similar but smaller holes, some 200 m. across, forming on Greenland glaciers when englacial lakes or water chambers drained, allowing their roofs of ice and firn to collapse. A.N.A.R.E. air photographs show two cases in which a pattern of darker ice, suggesting an incipient "ice doline", lies upstream of the collapsed ice. Even farther back along the direction of flow, melt lakes lie in deep hollows produced by, in one case, disturbed ice and in the other case a small nunatak, and it is apparent that the lakes receive drainage water from the surrounding ablation area. It is suggested that after the depressions fill with melt water, freezing proceeds rapidly at the surface but only slowly at the bottom of the bowl, where heat is conducted only slowly. The ice moves along with water trapped beneath the surface and if subsequent cracking, perhaps at the junction with the shelf, allows the water to drain away, the unsupported surface ice will subside to form an "ice doline". The fish-shaped pattern around the "ice doline" in the photograph is probably the shallower water of the original lake which has frozen solidly, and it could be the expansion of this re-frozen melt water which produces the raised edges around the hole.

No glaciological measurements have been made on the Amery Ice Shelf or its neighbouring slopes, but observations made at Mawson and Davis, which lie to the west and east respectively, raise certain problems.

Estimates of annual net accumulation made from photographs of icebergs near the shelf following Schytt lead to a figure of about 20 cm. of water. This compares with 36·5 cm. on the Maudheim ice shelf,[7] 20 cm. at "Little America V" on the Ross Ice Shelf,[8] and 16 cm. on the Filchner Ice Shelf.[9] Swithinbank[10] found the accumulation on the Maudheim ice shelf to be due directly to precipitation over the area, but the precipitation measured at Davis, 150 km.

* See p. 92. † Facing p. 34.

to the east of the Amery Ice Shelf, in 1957 was only 6·5 cm. of water. I precipitation over the Amery Ice Shelf is equally low, one has to postulat in contrast to Swithinbank,[7] that wind blown snow provides a large portio of the net accumulation.

Estimates of the movement of the ice shelf, taking account of the ice stream discharging into it and the accumulation on the surface, lead to the conclusio that it must move with a relatively high velocity, say 600 m. per year or more

Both the above are only rough estimates, but they do suggest that th Amery Ice Shelf may possess certain characteristics different from other ic shelves examined previously.

Acknowledgements

The authors wish to thank the Director of the Antarctic Division, Mr P. G Law, for making data available and for discussions on the subject. They would also like to acknowledge the immense amount of effort put into the exploratior of the Amery area by many A.N.A.R.E. men in the past few years. One o the authors is particularly grateful to F.-Lt. Douglas Johnston for his hel in making possible aerial exploration of the region.

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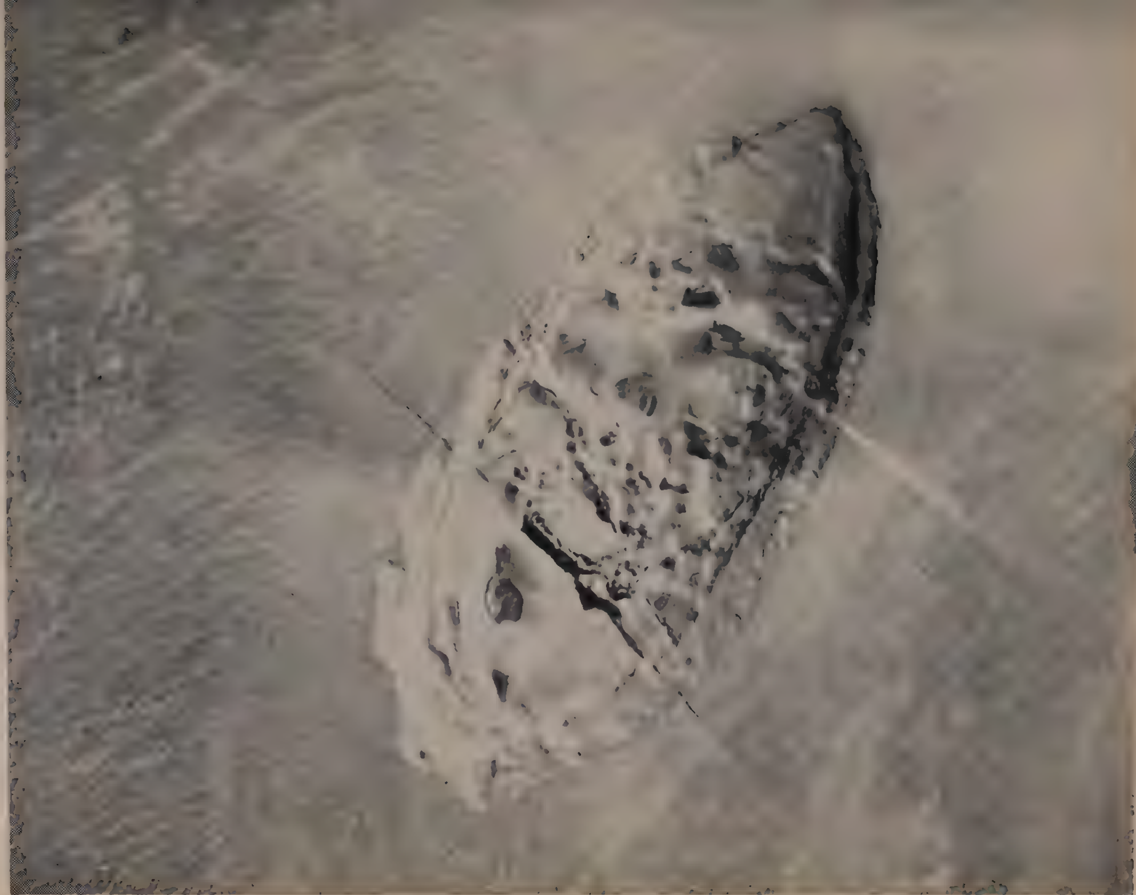


"Ice doline" in lat. 71° 20′ S., long. 68° 40′ E. Vertical air photograph

A.N.A.R.E. photograph

(*Facing p. 34*)

Polarbjørn at "Otterbukta", Dronning Maud Land, December 1959, with "Pingvin" station in background

Photograph by Norsk Polarinstitutt

NORWEGIAN AIR PHOTOGRAPHY IN DRONNING MAUD LAND: OPERATION "PINGVIN", 1958–59

BY BERNHARD LUNCKE[1]

[*MS. received 16 September 1959.*]

CONTENTS

Introduction

During the Norwegian–British–Swedish Antarctic Expedition, 1949–52, to Dronning Maud Land air photographs had been taken in support of ground survey parties by a Norwegian commercial flying unit in 1950–51,[2] and by a unit of the Royal Swedish Air Force in 1951–52.[3] A unit of the Royal Norwegian Air Force carried out a similar programme during the southern summer of 1958–59. It formed part of a Norwegian expedition, organized by Norsk Polarinstitutt and led by the author, which continued topographical survey west of previous operations.

Objectives

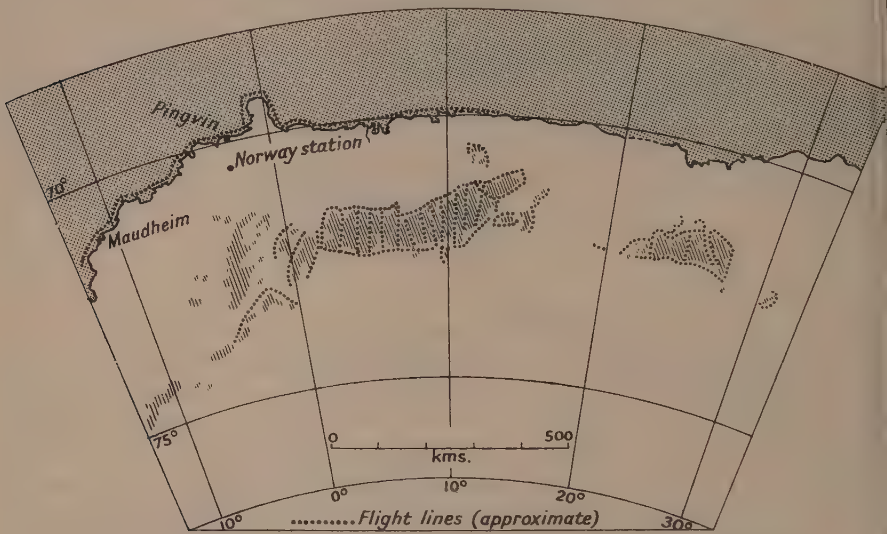
The objectives of Operation "Pingvin", in addition to transporting ground survey parties, were to take air photographs of three areas in Dronning Maud Land: (1) the ice front from Kapp Norvegia to long. 13° E., (2) the mountains between longs. 4° 30′ W. and 16° E., (3) the Sør-Rondane mountains between longs. 20° 15′ E. and 30° 3′ E. A preliminary map of the last area, based on two photographic flights made during the United States Operation "High-jump", 1946–47, was published in 1957 by Norsk Polarinstitutt, and, though not entirely satisfactory, was of considerable value during the flights in 1959. All three objectives were successfully achieved during the season.

Aircraft

Two ski- and wheel-equipped Otter aircraft were used for the operation, chosen because of their large carrying capacity and ability to land and take-off in a short distance. The use of identical aircraft presented several advantages including interchangeability of spare parts and emergency equipment. Each aircraft was fitted with a spare 400-litre fuel tank, giving it a safe range

[1] Norsk Polarinstitutt.
[2] *Polar Record*, Vol. 6, No. 45, 1953, p. 611.
[3] *Polar Record*, Vol. 8, No. 54, 1956, p. 230–36.

of about 2000 km., or 10 hours flying. Apertures for the cameras were cu in the bottom of the doors to avoid weakening the frames. Exhausti testing under field conditions was carried out in Jotunheimen, while tl personnel received intensive training in rescue and survival techniques.



Flight lines of the Norwegian air unit in Dronning Maud Land, 1959.

The aircraft were dismantled for transport, cocooned in plastic and packe in wooden crates, and carried on the foredeck of the expedition's shi *Polarbjørn*.

Personnel

Major G. Odden, R.N.A.F., commanded the unit and served as one of th two navigators, the other being Lieut. G. Hermansen. The two pilots we Captain G. Nilsen and Captain R. Alstad, and there was a ground staff of fiv Sigurd Svindland and the author operated the cameras. The leaders of the fiel parties were S. Helle, surveyor, and T. S. Wisnes, geologist.

Air photography

The cameras used were Zeiss R.M.K. air cameras, focal length 21 cm., with Zei "G" type, ×8, red filters. The exposure was at $\frac{1}{150}$ sec. with an aperture F 4·5. Gevaert "Aviphot Pan" 19 cm. films were used, and the size of th photographs was 18 × 18 cm. The cameras were fixed to a portable mountin in the aft compartment of the aircraft, and could be swung from side to si to obtain a full range of view.

Photographs were taken with a foreground overlap of 60 per cent, and fro a height of about 4000 m. A total of 3000 photographs was taken.

Air operations

Polarbjørn left Oslo on 1 November 1958 and reached the ice front of onning Maud Land in lat. 70° 08′ S., long. 2° 23′ E., after an attempt to d at Bouvetøya which was frustrated by the weather. Unloading began mediately, and one aircraft was airborne by 22 December and the second the following day. Both visited "Norway station", 30 km. inland, on ristmas Eve. A flying base, called "Pingvin", was set up about 3 km. ıth of the ice front. Accommodation consisted of a pre-fabricated hut m. square divided into radio room, dark room, store and living and sleeping om for twelve.

Between 25 December 1958 and 27 January 1959 there were 13 days on ich weather permitted flying. During this time 18 photographic flights re made, totalling 115 hours. Another 96 hours flying time was divided tween reconnaissance flights, the laying of depots, and the transport of ound parties. No mechanical troubles were experienced during the season.

The return voyage began on 30 January, and included another unsuccessful empt to land on Bouvetøya.

FIELD WORK

POLISH EXPEDITION TO VESTSPITSBERGEN, 1957–58

[Summarized from *Przeglad Geofizyczny*, Rocznik 3 (11), Zeszyt 2, 1958, and *Tr*
4 September 1958.]

An expedition, sponsored by the Polish Academy of Sciences [Polska Akad Nauk], spent from July 1957 to the autumn of 1958 in the region around Horns north-west Vestspitsbergen, as a Polish contribution to the I.G.Y. It was le S. Siedlecki. The area chosen was adjacent to that in which the Polish expediti 1934 had worked, and many of the investigations begun then were extended.

A reconnaissance party, led by S. Siedlecki, visited the area in 1956 and chose site for the main camp at Isbjørnhamna, near the mouth of Hornsund. Mete logical stations were later set up there and at the end of Hansbreen, and a gla logical station in the upper region of Werenskioldbreen, 420 m. above sea le Glaciological work was concentrated on Hansbreen which ends in the sea an therefore strongly affected by oceanic influences, and on Werenskioldbreen wh ending on land, is affected mainly by climatic conditions.

During the summer of 1957 thirty scientists carried out field studies, which cluded geomorphology under J. Dylik and A. Jahn, glaciology under A. Kos geology under K. Birkenmajer, terrestrial magnetism under K. Karazun, ma biology under M. Doroszewski, ornithology under B. Ferens and botany u A. Środón. A wintering party of ten remained and were joined by the second sum party, the whole expedition returning to Poland in August 1958.

DANISH SCIENTIFIC WORK IN GREENLAND, 1958

[Summarized from information supplied by Arktisk Institut, København.]

West Greenland

Archaeology. H. Larsen and a small party carried out an archaeological su in the inner branches of Godthåbs Fjord and Ameralik Fjord. Only one of the sites visited, at Itivnera, was found worth excavating. This proved to be the lar and best preserved Sarqaq site yet discovered in west Greenland. It contains first well-preserved organic material from this culture to be discovered in this reg including a human molar and a wolf canine.

Smaller sites of Sarqaq and Dorset cultures were discovered at Ikorfat Niaqornârssuk, on Nugssuaq peninsula, by A. Rosenkrantz and K. Skov.

Count Eigil Knuth worked on sites at Wolstenholme Fjord, Parker Snow and Kap Buddington.

C. L. Vebæk and two others continued the excavation of a Norse farm at Nars and visited sites at Østerbygd, Unartoq Fjord, Tasermiut Fjord, Tunugdli Fjord and Frederiksdal. A number of sites in the inner regions of the Tunugdli Fjord and Sermilik Fjord were seen during helicopter flights.

Botany. An expedition, led by Professor W. Böcher and sponsored by the Carls Foundation, spent July and August working in some thirty localities in coastal inland areas between lats. 65° and 70° N., in continuation of work done during summers of 1946 and 1956. The area is one in which the transition takes place Atlantic flora, of Arctic-alpine species, to continental flora, of Arctic spe Boundary lines between the flora were determined and large numbers of plants seeds were collected.

Geology. Parties from Grønlands Geologiske Undersøgelse [Geological Survey of Greenland] worked in four regions in west Greenland. (1) Egedisminde-Upernavik. A party led by Professor A. Rosenkrantz surveyed in the Nugssuaq peninsula and investigated sediments on the east side of Umivik Bay. Fossils were collected in both areas and magnetic investigations were made in basalt regions at Ikorfat and in Adatdalen by I. Marcussen. (2) Godthåb district. R. Lauerma completed the survey of the "Ipernatdome" area in Godthåbs Fjord. (3) Ivigtut-Nunarssuit area. Twenty-three geologists, under the direction of A. Berthelsen and divided into twelve parties based on Ivigtut, continued the survey begun in 1956. Survey for the map of the Ivigtut area was completed during the summer. (4) Julianehåb-Narssarssuaq area. Six groups worked under the direction of J. Bondam in this area. Bondam and six others took part in the boring operations of the Atomic Energy Commission on Kvanefjeldet near Narssaq.

All geological parties were again equipped with Geiger–Müller counters. O. Larsen collected samples for spectrochemical investigations in the Ivigtut area.

Glacial geology. A. Weidick completed his study of the marginal zone of the ice sheet and of the movement of glaciers in the Julianehåb district. He also surveyed marine beach ridges in the district.

Sociology. In 1955 a commission was set up by the Danish government "to plan and direct, on a scientific basis, the investigations necessary to ensure for the legislature and administration a solid foundation for the promotion of a steady and harmonious development in Greenland".

The following summer four members of the commission made a pilot study in the Holsteinsborg district. During the summer of 1958 a party consisting of three members of the commission, Professor F. Fram (Chairman), V. Goldschmidt, and Helge Larsen accompanied I. Glarborg and his wife (psychologists), G. Nellemann (ethnologist) and three Greenlanders who began a year's field work at Disko Bugt. The members of the commission returned to Denmark in the autumn. Field-work consists of three studies: (1) the reaction of Greenlanders to social, economic, cultural and judicial reforms introduced since 1950, (2) special problems such as alcohol, adopted children, venereal disease and others, (3) effects of new criminal and marriage legislation.

East Greenland

Botany. The Carlsberg Foundation Scoresby Sund Expedition, 1958, consisted of three botanists, E. Einarsson, K. Holmen and S. Lægaard, and a zoologist, U. Røen. Collections of vascular plants and mosses were made, and vegetation analyses carried out in several plant communities.

Freshwater biology. U. Røen, member of the Carlsberg Foundation Scoresby Sund Expedition, 1958, examined 67 freshwater localities on Ella Ø and other sites in the Scoresby Sund area, and collected a large number of samples for later examination.

Geology. Twenty-six geologists and assistants, under the direction of Lauge Koch, worked in various areas in east Greenland from a main base at Mesters Vig. The results of the season's work may be summarized as follows: (*a*) extension of survey on both sides of Nordvest Fjord for some distance towards the south, (*b*) the completion of the survey of the plutonic centre on Traill Ø and the plutonic centre west of the Werner plutonic centre, (*c*) the determination of the border between Permian and Trias, and the survey of these two systems for some distance west and south of Mesters Vig, (*d*) extension of inland survey in Jameson Land, (*e*) the discovery and photographing from the air of a large Pre-Cambrian folding in north-east Greenland. The existence of this folding was disclosed during flights between Dronning Louise Land, Station Nord and Vildt Land.

Glaciology. Børge Fristrup led a party which worked from a main base at Mitdluagkat glacier on Angmagssalik Ø. A photogrammetrical survey of the glaciers in the neighbourhood showed considerable recession since they were surveyed by M. Milthers during the 7th Thule Expedition, 1931–33.

Zoology. Christian Vibe and Torben Andersen investigated the Musk-Ox population in the inner reaches of Scoresby Sund Fjord, with assistance in manpower and air transport from Lauge Koch. Counting was carried out partly from four inland stations and partly by air, and it was estimated that there are about 3020 animals south of Ella Ø in the district.

Meteorology

The weather station at Narssarssuaq was taken over from the United States authorities in November, bringing the total of Danish stations to twenty-three, of which six are radiosonde stations. The station at Danmarkshavn was burned down early in the year but was replaced by August. Routine observations were carried out throughout the year at all stations.

THE CAMBRIDGE SVALBARD EXPEDITION, 1959

[By W. B. Harland. Accounts of the work of previous expeditions appear in the *Polar Record*, Vol. 9, No. 62, 1959, p. 463–64, and earlier numbers.]

This expedition was organized in the Department of Geology, Sedgwick Museum, Cambridge, to continue the stratigraphical, structural, and palaeomagnetic studies begun in Spitsbergen in 1938 and 1949 and carried on every summer since 1951. To get new material at several scattered localities for a number of investigations the expedition was divisible into four parties, A–D, each capable of working independently. The Spitsbergen work may be considered in four phases, with some interchange of members between each.

Members	Parties
W. B. Harland, Geologist, Leader	Leader Party D
Mary Dettmann, Geologist	A
D. L. Dickinson, i/c motor boat	D 1–4
J. L. Fortescue, Assistant geologist	C 1–4
P. F. Friend, Geologist, Deputy leader	Leader Party B
R. A. Gayer, Assistant geologist	B 1, B 2, D 3, D 4
D. G. Gee, Assistant geologist	B 1, B 2, D 3, D 4
D. J. Gobbett, Geologist	Leader C 1–3, B 4
R. V. Longe, Assistant geologist	A
D. W. Matthews, Assistant geologist	B 1, B 2, B 3, C 4
G. Playford, Geologist	Leader Party A
R. G. W. Prescott, Assistant geologist	D 1, D 2, B 3, C 4
M. S. Thornton, Assistant geologist	C 1–3, D 4
J. F. Wager, 2 i/c motor boat	D 1–3, C 4

C. B. Wilson, who was a member of the expedition, died in Cambridge before the expedition left.

Narrative

The whole expedition left Cambridge on 17 June 1959, arriving Tromsø on the 24th. Party A left Tromsø on 25 June by *Fortuna*, by kind arrangement of the Vervarslinga for Nord Norge (Mr S. W. Hansen), arriving Bjørnøya 27 June. The party left Bjørnøya by the same boat on 24 July and, after spending a week in Tromsø compiling field data, returned to Cambridge independently. During the four weeks on Bjørnøya detailed collections were made from four camps. From Herwighamna,

where Bjørnøya Radio and Meteorological Station had kindly made available a hut for use as a base camp, collections were made from successions of Upper Devonian, Carboniferous and Permian age. From the Fugleodden camp, specimens, principally from the Upper Devonian, were collected. From the camp at Mefaringen specimens of the Upper Devonian, Permian and Triassic rocks were obtained. In the Ellasjøen area specimens were collected from Cambro-Ordovician, Upper Devonian, Carboniferous and Permian strata.

Parties B to D left Tromsø by *Lyngen*, arriving Longyearbyen on 28 June. After reorganization, Party B continued on *Lyngen* with the intention of establishing a first base at Virgohamna but ice prevented this, and, by kind suggestion of Dr K. Z. Lundquist, the party was eventually transferred to *Minna* in Magdalenefjorden on 29 June. Depots for Party D were left at Ny Ålesund and Gravneset. Ice delayed *Minna*, which on 2 July was able to drop the party, with three small boats and outboard motors, at Biskayerhuken. Party B had planned to work in northern Andrée Land from an advanced base at Gråhuken and, after further delay due to sea ice, reached there on 10 July. In the meantime work had been carried out around Biskayerhuken and Raudfjorden. On 7 July the Biskayerhuken hut was totally destroyed by fire. In spite of this disastrous loss to workers along the north coast of Spitsbergen, the expedition losses were relatively light and, after notifying the authorities (via the Norwegian party at Birgerbukta) and ascertaining that nothing more could be done immediately, the party was able to proceed according to plan.

Parties C and D got the boats and motors ready at Longyearbyen. These included *Ingelin*, a 7 m. half-decked diesel powered motor-boat, which was purchased for this work largely from a D.S.I.R. grant, and used by the North-West Spitsbergen Expedition in 1958.

On the early morning of 29 June Parties C and D set off for Billefjorden with *Ingelin* and three small boats (two with outboard motors) in tow, carrying sledging equipment and supplies. Brucebyen was used as an advanced base from which, after beaching the boats, the group of seven, with three Nansen sledges and two small sledges, set off up the south side of Nordenskiöldbreen; then via camps by Ormstonfjellet, Ferrierfjellet, Bumerangkammen, east of Sedgwickjøkelen, Titanfjellet col, across upper Kvitbreen and down Oslobreen; they arrived at Kirtonryggen on the morning of 7 July.

At Kirtonryggen a service was held at the snow grave of C. J. B. Kirton[1] and a cairn was erected on a prominent Carboniferous outcrop north of the main cliff, with a bronze plaque as follows:

"CHRISTOPHER JOHN BLISSETT KIRTON, 17. 8. 1937–26. 7. 1958, EXHIBITIONER OF QUEENS' COLLEGE, CAMBRIDGE, WHO LOST HIS LIFE WHILE COLLECTING FOSSILS IN THE MOUNTAIN AFTERWARDS CALLED KIRTONRYGGEN AT THE FOOT OF WHICH HE IS BURIED. THIS PLAQUE WAS PLACED BY THE CAMBRIDGE SVALBARD EXPEDITION 1959."

Leaving Party C with ample supplies, Party D returned to Brucebyen on 13 July, leaving a depot at Bumerangkammen, and thence on to Longyearbyen on 16 July leaving boat, motor, and supplies at Brucebyen. Party D then travelled by motor boat via Kapp Linné, St Jonsfjorden, Ny Ålesund, Magdalenefjorden (Gravneset) and Biskayerhuken to Gråhuken, arriving on 24 July, and bringing supplies to Party B1 in Woodfjorden on the 25th.

In the meantime Party B had been working in north-west Andrée Land with two small boats and motors based on a series of fjord-side camps at Gråhuken, Grennadalen, Mushamna, Jakobsenbukta and Verdalen. Stratigraphical and structural studies were carried out in the Devonian Grey Hoek and Upper Wood Bay Series,

[1] *Polar Record*, Vol. 9, No. 62, 1959, p. 463–64.

and collections for palynological and palaeomagnetic, as well as general stratigraphica purposes, were made.

On 26 July, Parties B and D reorganized and the enlarged Party D2 crosse Woodfjorden to spend three days working round Bockfjorden, collecting fron Hecla Hoek schists, marbles and gneisses, and from Devonian rocks of the Red Ba Series, Kapp Kjeldsen divisions, etc. Thence they continued to inner Liefdefjorden where three further days were spent investigating similar rocks as they were foun to continue northwards. On 5 August Party D2 returned to Gråhuken where the met Party B2, which had continued structural and stratigraphical work in nort Andrée Land, based on Wijdefjorden and working down as far as Andredalen.

Leaving Gråhuken, Parties B and D recrossed Liefdefjorden and Party B continued work on the Devonian Wood Bay Series of Reinsdyrflya, while Party D returned to Biskayerhuken and to Virgohamna with a heavy load of specimens an surplus gear. The parties met again at Biskayerhuken on 7 August and continue working jointly, first on that peninsula and then round the shores of Raudfjorde from a camp at Alicehamna. Hecla Hoek schists and gneisses were investigated a well as the Red Bay Series. The Hecla Hoek rocks were further examined from camp at Birgerbukta by visits to Klovningen, Ytre and Indre Norskøyane and th neighbouring mainland. On 12 August the parties continued to Virgohamna wher they redivided, leaving Party B3 at Virgohamna to await the *Lyngen*. Observation on Hecla Hoek gneisses and granites were made by Party B3 round Smeerenburg fjorden.

Party D3 continued by motor boat, lightly laden, to Ny Ålesund and examined Hecl Hoek rocks at London and Kongsbreen. After leaving Kongsfjorden on 16 August Devonian, Culm and Hecla Hoek were collected round the shores to Engelskbukta and then, via Hermansenøya, to an anchorage east of Bullbreen in St Jonsfjorden The diesel engine was overhauled while rocks were examined within walking distance On 19 to 20 August the journey was made from St Jonsfjorden to Longyearbyen where Party B3 was already waiting. The latter was kindly taken up to Brucebye on the *Minna* in the course of a routine voyage, and Party D3 followed by moto boat, on 21 August. Party B3 investigated the Devonian inliers of south-eas Dickson Land while the others visited sections along Nordenskiöldbreen and Sven breen. The fjord off the front of Nordenskiöldbreen was surveyed with an Admiralt Lucas sounding machine.

Using the Kirtonryggen camp as an advance base, Party C studied the strati graphy of the Oslobreen Limestones and Dolomites (Cambrian and Ordovician) an collected about 200 fossil specimens. During the period 12 to 21 July a sledge journe was made northwards to Polarisbreen, where similar rocks were examined. The was much melting at this time and on the return journey to Kirtonryggen the surfac streams on Oslobreen were troublesome. The party finally left the Oslobreen are on 27 July and sledged back to Brucebyen via Kvitbreen and Grusdievbree arriving on 4 August. During this journey, three days were spent studying th Upper Hecla Hoek rocks of north-east Kvitbreen and two days collecting from th Carboniferous limestones south and west of Nordenskiöldbreen.

From Brucebyen palynological and fusuline specimens were collected from th Carboniferous. On 11 August, Party C left Brucebyen in a small boat with outboar motor for Bjonahamna, on the north shore of Tempelfjorden. About 300 Permia brachiopods were collected from Templet and the cliffs near Kapp Schoultz on th opposite side of the fjord. Strong winds caused a delay of two days at Bjonahamn and the return journey began on 16 August. Various sections were examined in th Carboniferous and Permian rocks of the southern part of Bünsow Land; camp were established at Gipsvika, Anservika, and Kapp Ekholm. From Kapp Ekhol more Carboniferous specimens were collected in north Gipsdalen.

On 24 August Parties B, C and D were reunited, and on 25 August together erected another, more accessible, memorial to C. J. B. Kirton in the form of a large cairn, with bronze plaque, on the skyline a little way up Ebbadalen. The reorganized parties C4 and D4 left Brucebyen on 26 August and Party C4, with two small boats and motors, collected from Permian and Triassic sections of Flowerdalen (Sassenfjorden). Party D4 returned to Longyearbyen with specimens and heavy gear, then back to Adventtoppen and to Deltaneset to collect from Janusfjellet, and to escort the small boats back to Longyearbyen on 29 August. The combined parties of 9 men left by *Lyngen* on 30 August.

On 27 August Party B4 crossed to the Russian coal-mining settlement of Pyramiden, where they were hospitably received and spent two days working on the Devonian and Permo-Carboniferous rocks in Mimerdalen. On 29 August they left Brucebyen by small boat and were forced by rough seas to land at Rundodden, south Dickson Land. For three days collections of ammonoids and fish were made from the Trias of Norskedalen and Studentdalen and the Permian rocks were examined. On 2 September they moved to the south of Hugindalen, in Dicksonfjorden, and geological work on the Devonian–Carboniferous rocks was continued. Finally three days were spent based at Kapp Wijk and collections were made from Trias and Permian beds. Party B4 arrived in Longyearbyen on 11 September and left by collier on 21 September.

Summary of geological work

Hecla Hoek rocks: (*a*) reconnaissance along coasts of north-west Spitsbergen for comparison of rocks and structure with those of Ny Friesland; (*b*) further investigation of Oscar II Land, continuing the work of the late C. B. Wilson; (*c*) completion of present field work on the Upper Hecla Hoek of Ny Friesland; (*d*) small collection for comparison from Bjørnøya.

Devonian Rocks: (*a*) structural and stratigraphical work in north Andrée Land (continuing that of 1958) and also briefly in Bockfjorden, Liefdefjorden, Raudfjorden and Kongsfjorden; (*b*) structural and stratigraphical work in Mimerdalen and west Billefjorden (continuing that of 1958) and in west Dickson Land; (*c*) Upper Devonian stratigraphy of Bjørnøya; (*d*) systematic samples for palynological studies from all areas.

Carboniferous and Permian Rocks: (*a*) palaeobotanical collections from Lower and Middle Carboniferous of Bjørnøya including systematic palynological sampling, the latter also from the Billefjorden Sandstones of Bünsow Land and Dickson Land in central Vestspitsbergen; (*b*) fusuline, coral, polyzoan and especially brachiopod collections from Middle Carboniferous to Upper Permian of the same areas and Kapp Schoultz.

Mesozoic rocks: reconnaissance, palynological (and other) collections were made from Sabine Land, and from the Triassic of south Dickson Land and Bjørnøya.

Altogether about 4500 specimens were collected, including about fifty oriented samples for palaeomagnetic work (mainly Polarisbreen Series and Old Red Sandstones, also late lavas) and five large samples of Caledonian metamorphic and igneous rocks for radioactive age determinations.

Acknowledgments

The Expedition is indebted to the Royal Society for a grant to cover the main travel costs and to both the Department of Scientific and Industrial Research and the Shell International Petroleum Company for grants covering the purchase of gear, some of which had been first used in 1958 and most of which will continue to

be available. Many firms made gifts of, or reductions for, supplies, which enable the undergraduate subscription to the expedition to be reduced to £50.

The Sysselmann placed at our disposal a hut in Longyearbyen, where partie lived in transit, and the Store Norske Spitsbergen Kulkompani helped by provisio of warehouse, storage and pier facilities. The Ny Ålesund administration gave u similar help. We are indebted to the Norskpolarinstitutt, and especially to Dr K. Z Lundquist, for transport of Party B in difficult conditions at the outset by *Minna*

VISIT OF HER MAJESTY QUEEN ELIZABETH II AND HIS ROYAL HIGHNESS THE DUKE OF EDINBURGH TO THE CANADIAN ARCTIC, 1959

[From information supplied by Canada House, London.]

During their tour of Canada in the summer of 1959, Her Majesty Queen Elizabeth I and His Royal Highness the Duke of Edinburgh paid a three-day visit to centre in the Canadian Arctic.

On 18 July they arrived by air at Whitehouse, Yukon, and, after being shown the museum, took a short trip by the White Pass railway to McCrae. Her Majesty became indisposed on the 19th and was represented by His Royal Highness a engagements during the remainder of the visit; she flew to Edmonton on 21 July to resume the tour.

On 19 July His Royal Highness flew to Dawson City where dredging operation were inspected, and a short stop was made at Mayo on the return to Whitehouse Next day at Yellowknife, Northwest Territories, the royal party was shown ove the Con mine, and then flew on to Uranium City, Saskatchewan, to inspect the Eldorado Mining and Refining Co.'s Mill and town site. The same evening Hi Royal Highness flew on to Alberta and rejoined Her Majesty.

CANADIAN OPERATION "HAZEN" 1959[1]

[By G. Hattersley-Smith.[2] Accounts of the work of the previous two years of this expeditio were published in the *Polar Record*, Vol. 9, No. 58, 1958, p. 26–27, and No. 62, 1959, p. 455–58.]

As part of the Canadian programme of International Geophysical Co-operation limited field work was carried on from the Lake Hazen I.G.Y. station from May t August 1959. R. B. Sagar, meteorologist and glaciologist, and J. M. Powell botanist and assistant meteorologist, were in the field for the whole summer; the were supported in part by the Arctic Institute of North America, and in part by th Defence Research Board of Canada. With J. W. Cox, T. A. Harwood and G. Hattersley Smith of the Defence Research Board, they arrived at the Lake Hazen base cam in a ski-wheel DC-3 (Dakota) aircraft of 102 Composite Unit of Air Training Com mand, R.C.A.F., and two days later were landed by the Dakota on Gilman Glacie at the 1957–58 camp site, where there was a cache of food and equipment. Durin the next two weeks, using an "Eliason" motor toboggan[3] to transport their store and equipment down the glacier, Sagar and Powell established their summer cam on gravel flats close to the glacier snout. The remainder of the party returned sout with the Dakota on 25 May. Micrometeorological observations, including radiatio measurements, were made at the glacier snout throughout the summer, and glacio

[1] Published by permission of the Chairman, Defence Research Board of Canada.
[2] Geophysics Section, Defence Research Board.
[3] *Polar Record*, Vol. 9, No. 60, 1958, p. 267–68.

logical measurements, in continuation of the 1957–58 work, were made on Gilman Glacier and on nearby snowdrift glaciers. Microclimatic and botanical studies were also carried out.

On 8 August, U.S.C.G.C. *Westwind*, Captain W. J. Conley, Jr., U.S.C.G., arrived in Chandler Fiord; the ship had left Thule on 1 August but was delayed by very heavy ice conditions in Smith Sound and Kane Basin. Eight tons of fuel and stores were landed at the base camp in 20 hours flying by a U.S. Navy helicopter. G. Hattersley-Smith, who had sailed from Thule in the ship, joined the field party at Lake Hazen. *Westwind* sailed from Chandler Fiord on 9 August. During the next two weeks the base camp was closed down for the winter; final ablation measurements were made on Gilman Glacier up to the equilibrium line at 4000 ft. (1280 m.); the camp at the snout of the glacier was evacuated; and the party of three walked round to the outlet of Ruggles River on the south shore of the lake, a total distance of nearly 60 miles from the base camp by land. Unlike conditions in August of 1957 and 1958, there was a concentration of more than nine-tenths ice over the lake as a whole; only in a 2-mile by 1½-mile stretch of open water near the outlet of Ruggles River was it possible for a float-plane to land to fly out the party. Ice also precluded the use of a boat to cross the lake. On 24 August a Canso aircraft of 102 C.U., under the command of F/Lt. W. Godby, flew the party out to Alert, whence they returned south via Thule and Resolute. Flying operations during both spring and summer were under the direction of the Air Officer Commanding, Air Transport Command, R.C.A.F.

JACOBSEN–McGILL ARCTIC RESEARCH EXPEDITION TO AXEL HEIBERG ISLAND, NORTHWEST TERRITORIES, 1959–61

[From information from F. Müller-Battle.]

Operations in 1959

This expedition to Axel Heiberg Island is a joint effort of the Department of Geography, McGill University, Dr F. Kenneth Hare, Chairman, and Dr George Jacobsen of Montreal, and is planned to extend over a period of three years. The aim is to study the Pleistocene and Recent evolution of this mountainous and strongly glacierized region of the Canadian Arctic. Investigations are to include glaciology, geomorphology, geology and allied sciences. The glaciological work will include glacial meteorology and ice-thickness determinations by seismic and gravity methods. The depth of permafrost will be established by deep drilling, followed by a study of the temperature profile of the drill holes. Drill cores will be analysed geologically. Large-scale glacier maps of selected areas will be produced using both air and terrestrial photogrammetry.

During the summer of 1959, a reconnaissance party consisting of the following members visited the area: F. Müller-Battle, leader (glaciology), W. P. Adams (geography), G. Jacobsen (permafrost research) and Professor E. H. Kranck (geology).

The party was flown to the meteorological station, Eureka, on Ellesmere Island, by 426 Air Transport Command, Royal Canadian Air Force and a DC-3 from Nordair Ltd., Montreal, between 13 and 21 July. From Eureka a Piper Super Cub, piloted by W. W. Phipps, ferried scientists and equipment over the ice cap of Axel Heiberg Island to a camp near Cape Levvel, at the entrance of Strand Fiord on the west coast of the island. The aircraft was equipped with large balloon tyres of 5 lb. pressure which enabled it to land and take off on unprepared terrain and in a very

short distance.[1] Fifty-eight landings were made on terrain ranging from soft beaches to rock outcrops and glaciers.

After a number of reconnaissance flights, the permanent base was established at the head of South Fiord in lat. 79° 25′ N., long. 90° 30′ W. This area has three types of glacier in proximity to each other: (1) an outlet glacier from the central ice cap (its tongue in apparent equilibrium), (2) a valley glacier of alpine character (in slight recession) and (3) a high altitude small corrie glacier (showing relatively strong recession in recent years). There are also a great number of gypsum intrusions.

During the summer a general reconnaissance was carried out and a survey of forty fixed points was made, using a Wild T2 theodolite.

Glacier measurements for a long-term study of accumulation, ablation and ice movement were initiated by inserting bamboo canes into the ice and surveying them. The canes were distributed in groups of five at different levels starting at the tongues of the three glaciers and rising to altitudes of 1400 m. The firn line varies in this area from 950 m. to 1050 m. The annual layering of firn and ice and its crystal structures were studied to a depth of 1·8 m. in the accumulation area of both the valley and ice cap glacier. Englacial temperatures were measured to a depth of 10 m. in the tongue area of the valley glacier.

Meteorological observations at the base camp below the glaciers (60 m.) were carried out at six-hourly intervals from 24 July to 26 August; a few readings are missing.

The geological reconnaissance centred in the South Fiord area and extended north-west to Middle Fiord and east to Mökka Fiord and Gibs Fiord. Special attention was given to the numerous gypsum intrusions and domes. After careful investigation, the site for next year's deep rock drilling was chosen. The use of the Piper Cub, sometimes for 24 hours a day, enabled geological investigations to be carried out in a short time which would have taken many months using conventional methods.

Field work ceased on 26 August when two Piper Cubs arrived from Resolute to evacuate Müller-Battle and Adams, the last two members of the party; Jacobsen and Kranck had left previously by the same means.

In preparation for next year's larger party (15 to 20 members) which plans to be in the field from April to the beginning of October 1960, two fibreglass houses, including laboratory facilities, a plywood hut, food and most of the equipment were shipped this summer to Eureka by the Canada Department of Transport icebreaker *d'Iberville*.

THE FALKLAND ISLANDS DEPENDENCIES SURVEY, 1957–58

[Summarized from information provided by the Colonial Office. An account of the Falkland Islands Dependencies Survey (F.I.D.S.) activities in 1956–57 was published in the *Polar Record*, Vol. 9, No. 60, 1958, p. 245–51.]

During the winter of 1957 eleven British stations were occupied by F.I.D.S. parties: Signy Island in the South Orkney Islands; Whalers Bay, Deception Island, and Admiralty Bay, King George Island—both in the South Shetland Islands; Hope Bay, Trinity Peninsula; Port Lockroy, Wiencke Island, and Arthur Harbour, Anvers Island—both in the Palmer Archipelago; Danco Island, Argentine Islands, Prospect Point, Detaille Island and Horseshoe Island—the last five off west Graham Land. Work also continued at the meteorological station at Grytviken in South Georgia.

[1] *Polar Record*, Vol. 9, No. 62, 1959, p. 459.

Relief of F.I.D.S. stations, 1957–58

The R.R.S. *Shackleton*, Captain N. R. Brown, left Southampton on 1 October 1957, carrying relief parties, stores and equipment. She arrived at Port Stanley, Falkland Islands, on 6 November and left on her first southern voyage on the 14th. She visited South Georgia between the 18th and 20th, and then sailed for the South Orkney Islands. After relieving the Signy Island station on the 23rd, she put a party of five men ashore on Powell Island on the 29th, and then proceeded round the north side of Coronation Island on her way to relieve the Hope Bay station on Trinity Peninsula. On the night of 29/30 November she was damaged by ice below the waterline, and her forward hold was flooded. Temporary repairs were immediately carried out by the crew and later, when the whale-catcher *Southern Lily* and H.M.S. *Protector* had arrived in answer to her distress signals, shipwrights and salvage equipment were transferred aboard her. Finally, escorted by the *Protector*, she was able to reach Stromness Harbour in South Georgia on 5 December. There she went into dry dock. She returned to Port Stanley on 23 December.

Professor J. B. Cragg of Durham University accompanied the *Shackleton* throughout her first southern voyage, making a survey of the opportunities for ecological research existing in the Falkland Islands Dependencies.

The R.R.S. *John Biscoe*, Captain W. Johnston, left Southampton on 21 October 1957, also with relief parties, stores and equipment. She called at Tristan da Cunha and South Georgia, and reached Port Stanley on 26 November. She left on her first southern voyage on 6 December, her passengers including the members of the Naval Hydrographic Survey Unit, led by Lieutenant C. J. C. Wynne-Edwards, R.N., and two members of F.I.D.S. who were attached to this Unit for the summer season. *John Biscoe* called first at South Georgia, and then went to the South Orkney Islands. On the 22nd she returned the Powell Island party to Signy Island. This party had carried out the geological mapping of southern Powell Island, Michelsen, Fredriksen and Christoffersen Islands, and had made biological observations; the survey programme had been seriously curtailed by bad weather. Before the end of December *John Biscoe* visited the stations at Admiralty Bay, Hope Bay, Deception Island, Danco Island and Port Lockroy. On the 29th a survey party was landed on Livingston Island. The Argentine Islands station was relieved between 1 and 9 January 1958, and the Naval Hydrographic Survey Unit was established at the disused F.I.D.S. station on Winter Island. The Anvers Island station was closed between 9 and 11 January. After two unsuccessful attempts, the Prospect Point station was relieved on 15 January. *John Biscoe* then took three F.I.D.S. members of that station to join the Naval Unit in the Argentine Islands. The Detaille Island station was relieved on 7 February. On the 14th *John Biscoe* left Detaille Island for the Horseshoe Island station in Marguerite Bay but, after being beset by ice for three days, she turned northwards again, reaching Port Lockroy on the 21st. On the 22nd the relief of Hope Bay was completed, but heavy pack ice in Antarctic Sound prevented the ship from reaching the View Point station in Duse Bay.

Dr. R. J. Adie, the chief geologist of F.I.D.S., from Birmingham University, accompanied *John Biscoe* throughout this voyage until 26 February when he transferred aboard *Protector*. The objectives of his summer visit were to obtain first-hand information about general F.I.D.S. scientific activities in the field, and to advise on the geological work being carried out from the F.I.D.S. stations. In the course of the summer season he visited all the stations except View Point, Horseshoe Island and Stonington Island.

On 5 March it was decided that *John Biscoe* should make one more attempt to relieve the Horseshoe Island station before returning to Port Stanley for replacement

stores. This was successfully achieved four days later. A survey party with a dep of food was also established at the Blaiklock Island hut. This party was compose of men from both the Detaille Island and Horseshoe Island stations. The existin station at Stonington Island (evacuated on 12 March 1950[1]) was re-occupied by party of six men on 10 March 1958, and a depot of food was landed on Pyrox Islan in Neny Fjord. On her way north *John Biscoe* again visited the stations at Prospec Point, the Argentine Islands, Port Lockroy, Danco Island, Deception Islanc Admiralty Bay and Hope Bay. She returned to Port Stanley on 28 March.

Two observers accompanied *John Biscoe* during the relief operations. They wer R. A. Butler of the United States Antarctic Projects Office, and a Chilean officer Teniente H. Cubillos.

Meanwhile *Shackleton* had left on her second southern voyage on 2 January 195 She visited Admiralty Bay on 5 January to transport a survey party of three me to Greenwich Island. She then called at Deception Island, Danco Island and Por Lockroy before returning to Port Stanley on 25 January.

Shackleton's third southern voyage was to South Georgia. She left Port Stanle on 27 January, arriving at Leith Harbour on the 31st. Between 1 and 4 Februar she charted Rosita Harbour in the Bay of Isles, visiting Grytviken on the 6th, an returning to Port Stanley on the 10th. She was setting out on her fourth souther voyage early in March when she developed engine trouble and, between 17 an 30 March, went into dry dock in Montevideo for repairs. She returned to Por Stanley on 5 April and sailed for the United Kingdom on the 11th.

The second southern voyage of *John Biscoe* began on 1 April. On the 4th th Greenwich Island survey party was evacuated from Yankee Harbour. Members o the Danco Island station were embarked on the 5th for temporary transfer to th Cape Reclus hut. After calling at Port Lockroy on the 6th, a depot of food was lai at Cape Willems in Gerlache Strait to be used later by members of the Danc Island station. The ship then visited the Argentine Islands and Prospect Point On the 7th the joint F.I.D.S.–Naval Hydrographic Survey Unit was evacuate from the Argentine Islands having completed its summer survey programme, an on the 8th the Danco Island party was established at the Cape Reclus hut. Afte calling at Deception Island, the Greenwich Island survey party was returned t Admiralty Bay on the 11th. Final calls were then made at Hope Bay, Signy Islan and South Georgia, and the ship returned to Port Stanley on the 21st. She saile for the United Kingdom, via South Georgia on 30 April.

Dr. D. J. Blundell of Birmingham University travelled at various times during th summer season on both *John Biscoe* and *Shackleton*, making palaeomagneti observations. He visited some sixty different localities, and collected orientate rock specimens for laboratory investigation.

Visit of British naval guardship, 1957–58

H.M.S. *Protector*, Captain A. R. L. Butler, R.N., left Portsmouth on 10 Octobe 1957, and reached Port Stanley during the first half of November. She left on he first southern voyage on 19 November with the Governor of the Falkland Island and Sir Eric Pridie, Colonial Office Medical Adviser, on board, reaching Grytvike in South Georgia on the 22nd. There arrangements were made for a naval surveyo Lieutenant M. J. Stumbles, R.N., to work in Stromness Bay and Cumberland Bay and a Royal Marine detachment was landed for a few days to support the surve party by erecting beacons. Her two helicopters were used to establish two surve base camps—in Husvik Harbour and at Grytviken—and to take air photograph

[1] See *Polar Record*, Vol. 6, No. 41, 1951, p. 23.

Falkland Islands Dependencies Survey station (Base Y) at Horseshoe Island, Graham Land

Photograph by F. Ryan

(*Facing p. 48*)

Falkland Islands Dependencies Survey station (Base J), Prospect Point, Graham Coast

'he Bay of Isles and Bird Island were visited on 25 and 26 November, and W. N. 3onner and an assistant were put ashore on Bird Island to study Fur Seals. *Protector* hen went to the help of *Shackleton* in the South Orkney Islands, escorting her back o Stromness Harbour in South Georgia. On 11 December *Protector* sailed for Port ›tanley, arriving on the 14th.

Protector left on her second southern voyage on 16 December, visited the Admiralty 3ay station on the 19th, and Deception Island on the 20th. Here, D. D. Hawkes vas landed in order to map the island geologically (he completed this task in mid-Aarch). A number of ice reconnaissance flights were made by *Protector*'s helicopters. she returned to Port Stanley on the 23rd.

She sailed on her third southern voyage on 30 December. Deception Island was ɩgain visited, and on 7 January 1958 the Royal Marine detachment was landed on ivingston Island for training and to help a F.I.D.S. survey party already working n the island. Admiralty Bay and Port Lockroy were also visited before the ship eturned to Port Stanley on 13 January.

Protector sailed on her fourth southern voyage on 15 January, and re-embarked he Royal Marine detachment on the 17th. A number of helicopter flights were nade to help the F.I.D.S. survey parties on Livingston and Greenwich Islands. 'urther visits were made to Deception Island. The ship returned to Port Stanley n 21 January.

After returning on 9 February from a visit to Montevideo *Protector* sailed from 'ort Stanley on her fifth southern voyage, again with the Governor on board.)uring the next three weeks she visited all the F.I.D.S. stations and field parties s far south as the Argentine Islands, and a number of Argentine and Chilean stations nd ships in the same area. On 28 February the joint F.I.D.S.–Naval Hydrographic urvey Unit was visited in French Passage. On 1 and 3 March one of *Protector*'s elicopters photographed from the air the whole area of French Passage over which he Unit had established survey control points, and which had not been covered by he Falkland Islands and Dependencies Aerial Survey Expedition (F.I.D.A.S.E.) luring the previous year. The *Protector* also ran lines of soundings in the western art of French Passage. She returned to Deception Island on 5 March and reached 'ort Stanley a few days later.

Protector sailed on her sixth southern voyage on 13 March. On the 15th the Livington Island survey party, with its equipment and dogs, were evacuated by helicopter ogether with an observer from the Deception Island Argentine station. Due to oor weather, the return of the party to Hope Bay was not completed until the 18th.)n the 19th the F.I.D.S. survey party on Greenwich Island was visited, and two '.I.D.S. surveyors were landed on Rugged Rocks, close north of Renier Point, in n attempt to extend the Livingston Island triangulation. This was unsuccessful ecause of bad weather. Finally *Protector* visited Deception Island, returned the rgentine observer to his station in Fumarole Bay by helicopter, and sailed the ame day for Ushuaia.

Towards the end of May 1958 two men from the F.I.D.S. Cape Reclus hut were emporarily stranded on Cape Murray. In addition, the conditions and dwindling ood supply at the Cape Reclus hut made the return of the whole party to Danco sland desirable. Between 20 and 23 May H.M.S. *Burghead Bay* tried to reach the rea, but the attempt was abandoned when the ship met heavy pack ice, accompanied y a sharp fall in sea and air temperatures, about fifty miles north-west of Smith sland. The F.I.D.S. parties, both from the Cape Reclus hut and from Cape Murray, ventually reached Danco Island safely on 27 May.

Summer survey operations, 1957–58

Despite frequent poor weather conditions, many delays to the ships caused by ic and the re-organization of the shipping programme following the damage to th *Shackleton* early in the season, great advantage was taken of the opportunities fo scientific and survey work by individual scientists visiting the Falkland Island Dependencies for the summer season only, and by detached survey and geologica parties which were put ashore in chosen localities by the ships in December o January and were taken off again in March or April.

Following the air survey of the South Shetland Islands and part of Graham Lan by F.I.D.A.S.E. in 1955–57,[1] the emphasis in the F.I.D.S. survey programme wa on triangulation in order to provide further control for the plotting of the ai photographs at a scale of 1:200,000. Some observations had already been taken b F.I.D.A.S.E. ground survey parties and it was planned that these should be extended

A party of six men was put ashore by *John Biscoe* at Hannah Point on Livingsto Island on 29 December 1957. They were H. W. Simpson, leader and medical officer N. A. Leppard and D. McCalman, surveyors, G. J. Hobbs, geologist, C. Johnston and R. W. Tufft, meteorological assistants. During the early part of Januar existing observed points were identified and additional cairns built. The surve observations began on 16 January but, because of poor weather, progress was slow On 22 February the party was reinforced by the arrival of W. W. Herbert, P. B Thompson and R. I. Walcott and the triangulation was completed by the end o February. The Greenwich Island survey party was twice visited in order to ensur that the triangulation link across McFarlane Strait should be successful. The geologica work was mainly concentrated in the relatively ice-free area of Byers Peninsula numerous sealers' remains, dating from the 1820's, were also found in this area. Th surveyors took full advantage of *Protector*'s helicopters for moving parties abou on Livingston Island, and for visiting Greenwich and Snow Islands. The whol party was evacuated by helicopter on 15 March.

A party of three men—G. J. Davey, surveyor, G. Monk and D. R. K. Stephens— was put ashore in Discovery Bay on Greenwich Island by *Shackleton* on 7 January During the next three months the triangulation of Greenwich Island and the lin with the Livingston Island scheme was completed. On 22 February Davey an Monk were taken in one of *Protector*'s helicopters to Robert Island where two surve stations were occupied, and the triangulation was successfully extended. An attemp to link up with the King George Island triangulation was only partially successfu because of poor visibility. On 28 February Stephens and Monk were replaced b J. Ketley and J. S. Madell; on 3 March G. C. Rumsey replaced Madell; and on 1 March Hobbs, the geologist with the Livingston Island party, joined in place o Rumsey. They were finally evacuated from Yankee Harbour by *John Biscoe* on 4 Apri

The work of the Naval Hydrographic Survey Unit off the Graham Coast i January–April 1958, in which five members of F.I.D.S. took part, has already bee described.[2] Working first from the Argentine Islands and later from a camp in th Sanctuary Islands, the triangulation of the whole area between Lemaire Channe and the camp was observed, and was connected with the 1957 triangulation northwards from the Prospect Point station. Lemaire Channel, French Passage, Penol Strait and northern Grandidier Channel were sounded. A reconnaissance into Darbe Bay in the Unit's launch to assess the possibility of extending the triangulatio southwards as far as Detaille Island indicated that this would be possible. R. Curti extended his 1957 geological observations northwards to Lemaire Channel.

[1] See *Polar Record*, Vol. 8, No. 54, 1956, p. 237–45, and Vol. 9, No. 58, 1958, p. 28–31.
[2] See *Polar Record*, Vol. 9, 1959, No. 61, p. 341–42, and No. 62, p. 446–49.

Activities at F.I.D.S. stations, 1958

Routine meteorological observations were continued throughout the year at the occupied stations at Signy Island, Deception Island, Admiralty Bay, Hope Bay, Argentine Islands, Detaille Island and Horseshoe Island. View Point in Duse Bay was occupied throughout the year by Hope Bay personnel who also made meteorological observations at this satellite station. Radio-sonde ascents and an extensive programme of geophysical observations were made at the Argentine Islands. Ionospheric work was carried out at Port Lockroy. Routine weather forecasts were made from Grytviken. All of these stations contributed to the International Geophysical Year (I.G.Y.) scientific programme.

Regular sea ice observations were made at all the occupied stations.

The I.G.Y. glaciological programme in South Georgia was hampered by the premature return of one of the two glaciologists, but a F.I.D.S. geologist, H. M. Noble, was transferred from Admiralty Bay to work with J. Smith. Detailed observations were made on the Hodges and Nordenskjöld Glaciers.

A re-survey of Signy Island was completed in mid-March, and was linked with the 1957 Coronation Island survey.

At the Admiralty Bay station on King George Island detailed studies of one valley and one cirque glacier in the vicinity of Visca Anchorage were completed by H. M. Noble in March 1958. A triangulation of the whole island was carried out during the year. In January and February J. S. Bibby undertook a programme of geological mapping and collecting in Ezcurra Inlet. He returned to the same area for nearly three weeks in December after wintering at Hope Bay.

The early part of the year was occupied by members of the Hope Bay station in relaying stores to View Point which the relief ships had been unable to reach, but from May onwards survey and geological parties were working almost continuously in Trinity Peninsula and the Prince Gustav Channel and James Ross Island areas. Preliminary triangulation was done in Trinity Peninsula north of the East and West Russell Glaciers. Astronomical fixes were made at Cape Longing. Geological mapping was carried out in western James Ross Island and between View Point and Church Point on Trinity Peninsula.

During February the survey of Paradise Harbour was nearly completed by members of the Danco Island station, and the triangulation was linked with the F.I.D.A.S.E. triangulation at Breakwater Island off Wiencke Island. Between 5 April and 25 May all members of this station were at Cape Reclus; a skeleton triangulation of Charlotte Bay was completed, and some geological work was carried out. Bad weather prevented more extensive journeys being made. Some glaciological work was done at Danco Island during the winter. Between 15 October and 5 November G. D. Boston, D. G. Evans, G. J. Hobbs and E. B. Jones visited Paradise Harbour. Although they were unable to reach the depot at Cape Willems the triangulation and geological mapping in this area was completed.

In February three members of the Prospect Point station, led by R. Miller, visited Holtedahl Bay and pioneered a route inland from Conway Island for about 4 miles. A subsequent study of air photographs indicates that this is the only difficult part of a possible route to the plateau by way of Hugi Glacier. During the rest of the year survey work was limited by unstable sea ice conditions. In May Holtedahl Bay was again visited and a depot was established at Rugg Peak; the party was away from the station for only ten days. In June P. Catlow and J. F. S. Martin laid a depot on Marie Island. Further attempts were made to reach Holtedahl Bay, and to extend the previous year's triangulation westwards from Dodman Island and southwards to link with the Detaille Island triangulation scheme, but with little success.

In February two members of the Detaille Island station—F. Oliver and J. W.

Young—were embarked on *John Biscoe* to work with two members of the Horseshoe Island station—J. M. Rothera and R. H. Hillson—at the Blaiklock Island hut. Since the ship could not get into Marguerite Bay in February, they did not reach the hut until 8 March. Survey work was first carried out in the South Heim Glacier area and later on the west coast of Arrowsmith Peninsula. Oliver, Rothera and Young returned to Detaille Island on 8 August after leaving Hillson at Horseshoe Island. The sea ice in the vicinity of Detaille Island did not become firmly established until mid-July. During this month an extensive programme of survey and geology was initiated. On 16 July B. L. H. Foote and J. G. Graham left for Hanusse Bay. They returned towards the end of the month. Several geological journeys were also made in the Lallemand Fjord area at this time. On 10 August Foote and P. O. White left for Darbel Bay, followed on the 12th by D. C. Goldring and C. Johnson. Goldring and Johnson returned to Detaille Island on 21 September. The other two members of the party were away until 1 October. Rothera and Young worked in Hanusse Bay during much of September and October. In October, Graham, Oliver and R. Perry established a depot at Lampitt Nunatak. At the end of October Rothera and Johnson returned to the Blaiklock Island hut to do further survey work in the Laubeuf Fjord area. In November and December, Foote and Golding visited Darbel Bay, the southern Biscoe Islands and Hanusse Bay, returning to Detaille Island on 20 January 1959. During December Graham, Oliver and White travelled to the Graham Land plateau by way of Erskine Glacier, then northwards to Leppard Glacier, returning on 13 January 1959 by the Murphy Glacier route. As a result of these journeys Foote completed the triangulation in the area bounded by Detaille Island, Cape Rey, northern Darbel Bay, the eastern side of the southern Biscoe Islands and the Sillard Islands, and plane-table surveys were made of all the islands in this area which were not covered by the F.I.D.A.S.E. air photography in 1956–57. This same area and the Hanusse Bay and Lallemand Fjord areas were mapped geologically. Rothera completed the triangulation of Arrowsmith Peninsula. He also made a traverse linking the islands not covered by air photography in Hanusse Bay, and a second traverse covering the gap in air photography at the southern end of Lallemand Fjord, and linking it with Erskine's traverse of the previous year between Jones Channel and Blind Bay. The geological mapping and a large-scale local survey of the Detaille Island area, to correct the inconsistencies of earlier maps, was also completed.

On 27 May three members of the Horseshoe Island station—S. E. Black, D. Statham and G. Stride—set out for Pourquoi Pas Island on a depot-laying journey to the Dion Islands. That same night a northerly gale broke up the sea ice and carried it out to the south-west. When no subsequent news of the men was received, search parties from Horseshoe, Detaille and Stonington Islands were organized, but their search was unsuccessful. It is assumed that the missing men had camped on the sea ice and were caught in the break up.

Survey and geological programmes at Stonington Island were initiated in April. During the next two months a number of relatively short journeys were made to the plateau by way of Northeast Glacier, and to Neny Fjord, the objective being to find a way into Neny Trough. Between 16 and 28 August P. McC. Gibbs and P. D. Forster surveyed Neny Fjord. In September K. Hoskins and B. R. Roberts worked on the geology of the Black Thumb Mountain area, and a second geological party, consisting of N. A. Procter and H. T. Wyatt, travelled by way of Mushroom Island to the Rhyolite Islands in George VI Sound. Additional geological observations were made between these islands and Mount Guernsey. At the same time the support party found a route on to the Wordie Ice Shelf at its north-eastern corner. The geological mapping of Neny Fjord was continued in December. Meanwhile, on 7 November Gibbs, Forster and Wyatt set out on the main summer survey journey.

After travelling by way of the Wordie Ice Shelf to the Kinnear Mountains they pioneered an inland route round the back of the ice shelf till they reached Clarke Glacier. From here they made their way through Windy Valley to the head of Mobiloil Inlet, surveying the extensive glacier system in this area. They returned to Stonington Island on 4 January 1959 by way of Neny Trough, Beehive Hill and Northeast Glacier, having made extensive additions to the existing map of the Fallières and Bowman Coasts.

APPENDIX. *Wintering parties at F.I.D.S. stations*, 1958

Port Lockroy, Wiencke Island, Palmer Archipelago (Base A)

J. M. Smith, Officer-in-charge and scientific assistant (senior)
H. A. D. Cameron, Scientific assistant
M. A. Crockford, Radio operator mechanic
D. M. Price, Diesel electric mechanic
J. Tinbergen, Scientific assistant

Deception Island, South Shetland Islands (Base B)

J. E. Dagless, Officer-in-charge and meteorological assistant
R. D. Clements, Diesel electric mechanic
K. V. Gibson, Meteorological assistant
P. J. Hodkinson, Meteorological assistant
V. O'Neill, Radio operator mechanic
P. R. Rowe, Radio operator mechanic
A. J. Witcombe, Meteorological assistant (senior)

Hope Bay, Trinity Peninsula (Base D)

D. McCalman, Officer-in-charge and assistant surveyor
T. N. K. Allan, Medical officer
J. S. Bibby, Geologist
S. C. B. Blake, Radio operator mechanic
H. J. Dangerfield, Radio operator mechanic
R. M. Koerner, Meteorological assistant (senior)
M. J. F. Reuby, Meteorological assistant
M. D. Rhodes, Meteorological assistant
L. Rice, Surveyor
T. H. H. Richardson, Meteorological assistant
R. W. Tufft, Meteorological assistant
J. S. Walsh, Diesel electric mechanic
J. D. J. Wildridge, Meteorological assistant
P. L. Woodall, Meteorological assistant

Stonington Island, Fallières Coast (Base E)

P. McC. Gibbs, Officer-in-charge and assistant surveyor
P. D. Forster, Assistant surveyor
K. Hoskins, Geologist
N. A. Procter, Geologist
B. R. Roberts, Radio operator mechanic
H. T. Wyatt, Medical officer

Argentine Islands, Graham Coast (Base F)

J. C. Farman, Officer-in-charge and scientific officer
K. R. Bell, Diesel electric mechanic
E. C. J. Clapp, Radio operator mechanic
B. D. Giles, Meteorological assistant (senior)
J. M. Hunt, Meteorological assistant
P. McN. Jones, Medical officer
C. W. Pearson, General assistant/cook
G. J. Roe, Meteorological assistant
J. B. Shaw, Meteorological assistant
D. A. Simmons, Assistant scientific officer
C. M. Smith, Meteorological assistant

APPENDIX (*cont.*)

Admiralty Bay, King George Island, South Shetland Islands (*Base G*)

D. R. K. Stephens, Officer-in-charge and meteorological assistant
D. R. Bell, Meteorological assistant
G. J. Davey, Assistant surveyor
J. L. Franks, Meteorological assistant (senior)
A. Gill, Meteorological assistant
G. Monk, Radio operator mechanic
C. D. Souter, Diesel electric mechanic

Signy Island, South Orkney Islands (*Base H*)

P. A. Richards, Officer-in-charge and meteorological assistant (senior)
B. Beck, Meteorological assistant
G. D. Mallinson, Radio operator mechanic
A. Sharman, Meteorological assistant
J. W. Stammers, Meteorological assistant
G. F. C. White, Diesel electric mechanic

Prospect Point, Graham Coast (*Base J*)

G. K. MacLeod, Officer-in-charge, general assistant and mountaineer
P. Catlow, Radio operator mechanic
T. A. Hanson, Assistant surveyor
K. Kenyon, General assistant
J. F. S. Martin, Assistant surveyor

Danco Island, Danco Coast (*Base O*)

G. D. Boston, Officer-in-charge, general assistant and mountaineer
D. G. Evans, Assistant surveyor
G. J. Hobbs, Geologist
E. B. Jones, Radio operator mechanic
J. F. Malden, Diesel electric mechanic

Detaille Island, Loubet Coast (*Base W*)

B. L. H. Foote, Officer-in-charge and assistant surveyor
D. C. Goldring, Geologist
J. G. Graham, Medical Officer
C. Johnson, Radio operator mechanic
F. Oliver, Diesel electric mechanic
R. Perry, Meteorological assistant (senior)
J. M. Rothera, Assistant surveyor
P. O. White, Meteorological assistant
J. W. Young, Meteorological assistant

Horseshoe Island, Fallières Coast (*Base Y*)

J. Paisley, Officer-in-charge and meteorological assistant
S. E. Black, Meteorological assistant
R. H. Hillson, Meteorological assistant
D. W. McDowell, Meteorological assistant (senior)
E. R. McGowan, Radio operator
D. Statham, Meteorological assistant
G. Stride, Diesel electric mechanic

Grytviken, South Georgia (*Base M*)

D. Borland, Forecaster-in-charge
J. Ford, Meteorological assistant (senior)
J. Cochrane, Meteorological assistant
A. Freer, Meteorological assistant

AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITION, 1958–59

[By P. G. Law. Previous accounts of these expeditions were published in the *Polar Record*, Vol. 9, No. 60, 1958, p. 251–54, and earlier numbers.]

During 1958 Mawson station was manned by a party of twenty-eight men led by Ian Adams. Field work began in the autumn. On 17 March a party of five men made a journey to Mount Henderson, taking gravity observations along a line of glaciological flow stakes between Mount Henderson and Casey Range. The party also made seismic soundings in this area and found that the rock bed lay between 100 ft. above, and 300 ft. below, sea level.

Throughout the winter the satellite station at Taylor Glacier was manned and auroral and meteorological studies were carried out. Emperor Penguin studies at the nearby rookery were also continued.

On 30 September, a party of five led by Ian Adams set out south along long. 62° E., following the route established in the previous year. The party, travelling by tractor train, encountered bad weather and surface conditions but managed to reach a point 237 miles south of Mawson, taking gravity measurements in the course of the journey. They then turned northward and, taking a route about 30 miles west of the outward track, returned to Mawson carrying out seismic soundings *en route*. The ice proved to have a maximum thickness of 8500 ft. and, at one point extended 400 ft. below sea level. The party reached Mawson on 17 January 1959 after 110 days in the field.

Throughout the year the R.A.A.F. Antarctic Flight ably assisted the ground parties. Support was given to the southern party in the form of reconnaissance and supply-dropping, and the surveyor and geologist were flown to selected points to take astro-fixes and make geological observations. During the year the total number of flying hours for the aircraft exceeded 1000, including several photographic runs.

A second field journey was undertaken during the summer, by dog sledge from Amundsen Bay to Mawson. During September 1958, two depots of food and provisions were established along the proposed route by Beaver aircraft and during November three men were flown into Amundsen Bay, followed by sledges, dogs and other equipment. On 28 November the party, led by Graham Knuckey, left Amundsen Bay to travel through the Tula Range and then through a chain of mountains and nunataks back to Mawson. The party, which included a surveyor and geologist, visited rock exposures which were inaccessible by other means of transport, returning to Mawson on 21 January 1959.

Scientific work continued at Mawson and Davis on meteorology, the aurora, cosmic rays, ionospheric winds, geomagnetism, seismology and physiology.

A.N.A.R.E. relief voyages: Macquarie Island, Davis and Mawson

During relief operations 1958–59, the Australian Government chartered two vessels—M.V. *Thala Dan* and *Magga Dan*. *Thala Dan* was to relieve the Macquarie Island station, Davis and Mawson, while *Magga Dan* was to land the Australian party who would take over "Wilkes" station from the United States, and was to overhaul the automatic weather station installed at Lewis Islet.

The A.N.A.R.E. expedition to Macquarie Island, led by D. F. Styles, left Melbourne in the *Thala Dan*, Captain H. C. Petersen, on 26 November 1958, reaching the island on 1 December.

The 1959 wintering party at Macquarie Island comprised:

T. R. Harwood, Officer in charge
B. G. Bell, Technical officer
I. K. Black, Senior weather observer
O. Bode, Weather observer
G. Casasayas, Weather observer
C. J. Cooke, Radio supervisor
Dr S. Csordas, Medical officer
A. B. Dean, Carpenter
N. E. Foley, Weather observer
R. J. Hollingsworth, Physicist
D. O. Keyser, Radio officer
K. R. McDonald, Radio officer
J. E. M. Munro, Physicist
J. O'Keefe, Cook
H. T. Redfearn, Diesel mechanic
D. W. Smith, Senior technician (Radar)
P. H. Sulzberger, Physicist

During the changeover, a party of surveyors using a helicopter and a telluromete made an accurate survey of the eastern coast of the island. The ship left on 14 Decem ber, reaching Melbourne four days later.

The A.N.A.R.E. relief expedition to Mawson and Davis left Melbourne o 26 December in *Thala Dan*. The expedition was again led by D. F. Styles. Pack ic was first encountered on 10 January 1959 and the following day a brief visit wa made to "Mirnyy" station.

On 16 January, when the ship was approaching Davis station, it struck a sub merged rock off Turner Island, holing the hull and losing about 60 tons of bunke oil. Repairs were soon made, though the expedition's programme of exploratio had to be curtailed.

The fast ice in the region of Davis and Mawson proved to be the heaviest encoun tered by A.N.A.R.E. expeditions since 1954, and *Thala Dan* spent several day trying to cut a path through the ice to Davis. However, on 26 January, a gale brok up the ice and the following day unloading operations began. The change-over wa completed on 31 January.

The 1959 wintering party at Davis comprised:

H. O. Steiger, Officer in charge and Senior weather observer.
C. Braunsteffer, Weather observer
J. Eadie, Cook
H. P. Fuller, Radio supervisor
J. Keuken, Weather observer (Radio)
A. Newman, Diesel mechanic
M. O'Gorman, Weather observer
R. Torckler, Radio officer

On 1 February the ship left for Mawson, anchoring in Horseshoe Harbour on th 4th. As the ice in the harbour had still not broken out, unloading of the 900 tons o stores, fuel and scientific equipment had to be carried out over the sea ice. Durin operations one Weasel broke through the weak ice and sank in the sea, but wa subsequently rescued. An endless cable, driven by the ship's winches, was rigge between the ship and the shore to facilitate unloading; this towed cargo sledge across the ice. The landing of a 7½-ton caterpillar tractor by this means was a ver ticklish operation.

The 1959 wintering party at Mawson comprised:

J. M. Bechervaise, Officer in charge
C. Armstrong, Surveyor
F/O. G. A. Banfield, Second in charge Antarctic Flight
Sgt. S. Bell, Radio fitter
Dr G. M. Budd, Medical officer
M. J. Cosgrove, Radio supervisor
R. Dunlop, Physicist
H. Evans, Radio officer
F. van Hulssen, Technical officer
M. Kirton, Physicist
J. M. Lawrence, Assistant diesel mechanic
Sgt. H. L. Macintyre, Engine fitter
E. L. Macklin, Radio officer
D. J. Norris, Physicist
L. W. Onley, Weather observer
K. Peake-Jones, Weather observer
H. L. Price, Senior diesel mechanic
Sgt. R. T. Rippon, Airframe fitter
Sq.Ldr. J. C. Sandercock, O.C. Antarcti Flight
A. Sawert, Radio officer
B. H. Stinear, Geologist
P. Teyssier, Cook
E. Widdows, Meteorologist

On 14 February the *Thala Dan* left Mawson, calling again at Davis on 17 February to install two new huts and leaving for Melbourne on 19 February.

A.N.A.R.E. relief voyage—"Wilkes"

The 1959 A.N.A.R.E. expedition to "Wilkes", led by Phillip Law, left Melbourne on 6 January in *Magga Dan*, Captain H. Møller-Petersen. It had three objectives: to re-supply and take over the United States base at "Wilkes"; to overhaul the Lewis Islet automatic weather station; and to explore the unknown coast of Oates Land.

The pack ice was first encountered on 13 January and the ship reached Lewis Islet the same day. The automatic weather station, which had been installed the previous year, had failed to transmit any radio messages after May 1958. The breakdown was found to be due to two of the station's aerial masts having been blown down in addition to electronic and instrument failures. Temporary aerials were erected, the automatic mechanism was overhauled, and when the expedition left the island on 15 January the station was operating again.

After paying a brief visit to the French station at "Dumont d'Urville" *Magga Dan* sailed to "Wilkes", which was reached on 25 January. Change over operations began immediately. Radio aerials were re-orientated to face Australia, new radio equipment was installed, glaciological investigations were carried out and air photos were taken from the Auster aircraft. The United States Navy icebreaker, *Staten Island*, arrived on 2 February and two days later her captain, Commander Price-Lewis, representing the United States Government, officially handed over the custody of the station to Phillip Law who accepted on behalf of the Australian Government.

The 1959 wintering party at Wilkes comprised:

W. R. J. Dingle, Officer in charge
W. H. Alderdice, Senior weather observer
Dr J. Boda, Medical officer
H. Brandt, Diesel mechanic
G. P. de la Harpe, Physicist
J. V. Denholm, Physicist
A. S. Flett, Radio officer
A. L. Giddings, Cook
K. Hardy, Weather observer
R. L. Harvey, Radio officer
A. C. Marriner, Radio supervisor
H. R. Robinson, Senior diesel mechanic
I. M. Tod, Weather observer
R. Underwood, Physicist
Cpl. J. Williams, Diesel mechanic

Three Americans were also included in the wintering party:

H. L. Hansen, Meteorologist
H. M. Nye, Electronics technician
R. L. Penney, Biologist

On 5 February *Magga Dan* left "Wilkes", paying a brief call at Lewis Islet again on 9 February to install permanent aerials which had been prepared at "Wilkes". That night course was set for Oates Land.

The Wilson Hills were first picked up on the ship's radar on 18 February and the following day land was sighted, though ice conditions in the area appeared very unfavourable. On 20 February, as a result of a reconnaissance and photo-survey flight made by Sqd.Ldr. Douglas Leckie and Phillip Law, the ship was able to push through the ice to the coast, and tie up alongside a narrow strip of fast ice at the foot of a steep nunatak, just west of a projecting glacier tongue. A landing was made on the mainland and the Australian flag was raised. An astro-fix gave the position of the landing as lat. 69° 9·3′ S., long. 157° 8·7′ E., indicating an error of about 45 minutes in the position of the Wilson Hills on present charts.[1]

[1] Based on Pennell's observations in 1911.

The following day magnetic declination measurements were made, and geological and biological investigations were carried out. A cairn was built and a record and an Australian flag were deposited inside it. A second aircraft flight was made by Leckie and Law for 70 miles west of the landing. Upon their return the ship steamed around to the eastern side of the glacier tongue and carried out a coastal survey, with soundings, in an eastward direction.

On 22 February the expedition left Wilson Hills, and after paying a brief call at Macquarie Island on 27 February, set sail for Australia, berthing at Hobart on 3 March.

INTERNATIONAL GEOPHYSICAL YEAR, 1957; ANTARCTICA, 1958

[The scientific activities of the International Geophysical Year officially ended on 31 December 1958. The following accounts of the activities of nations operating in Antarctica during the I.G.Y. are continued until the departure of the I.G.Y. parties at the end of the 1958–59 southern summer. Details of Australian activities are given elsewhere in this issue.]

Belgium

During March 1958 journeys were made both by dog and mechanical sledges. J. Giot and E. Picciotto took two dog sledges out for a ten-day training run, while G. de Gerlache, R. Carels, C. Hulshagen, Prince de Ligne, J. Loodts and H. Vanderheyden made a 400 km. trip south with two Sno-cats. They were away from base for 20 days and discovered a chain of mountains stretching east to west. The Sno-cats were taken up a glacier between these mountains and the route flagged for future use. A depot of 4000 litres of fuel was set up about 100 km. from Base "Roi Baudouin" for use the following summer. In April the Sno-cats made two trips to Breidvika to fetch seal meat for the dogs; one of the vehicles broke down on the second return journey and had to be left behind. It was eventually repaired and brought back to base on 20 August. Weather conditions during August were the worst yet encountered, with 12 days of blizzard and temperatures reaching $-45°$ C. A Sno-cat trip to "Baie Roi Leopold III" was immobilized for 6 days in a blizzard. Conditions improved in October and both the Auster and the helicopter were used again. De Ligne and de Maere made photographic flights along the coast, and a reconnaissance over the mountains to the south which had been discovered earlier in the year. The helicopter, piloted by de Gerlache, was used to carry Cabes and Loodts on field trips. On 29 October Hulshagen, Carels and Loodts left base with one Sno-cat and one Muskeg (the second Sno-cat was permanently out of commission) on the main southern journey of the year. They were snow-bound for some days only 13 km. out, but reached the depot, which had been set up in March, on 3 November. The next information available is dated 5 December when de Gerlache, de Ligne, Loodts and Hulshagen set off on a reconnaissance flight from "D3", a depot about 200 km. south-east of "Base Roi Baudouin". The aircraft did not return and an appeal was made by radio for air support from other I.G.Y. stations. A D.C. 47, piloted by V. Perov, from the Soviet station at "Mirnyy" arrived on the 13th, and, next day spotted the grounded Auster. This proved to contain a message from de Gerlache stating that the party had set out on 11 December to walk to "D3", a distance of some 120 km. The party were finally sighted and rescued on 15 December. A map resulting from these journeys was published in 1959.

The *Polarhav*, carrying the twenty-two members of the 1959 expedition, was beset 30 miles from "Base Roi Baudouin" on 29 December. She drifted during January 1959 and was eventually rescued by U.S.S. *Glacier* and *Edisto*, with the loss of *Glacier*'s helicopter. Ice was too thick for *Polarhav* to enter Breidvika so her cargo

was transferred and transported to the Belgian station in *Glacier*. The 1959 wintering party left Breidvika on the *Glacier* on 23 February and were later transferred to *Polarhav*.

France

In addition to the disciplines studied during 1957 the following were added in 1958; ozone measurements and the recording of telluric currents and of meteorites.

On 7 November 1958 G. Rouillon and a party of four left "Dumont d'Urville" station with three Weasels on a southern journey. They reached "Charcot" station on 4 December and went on for a further 200 km. southwards. On their return they closed "Charcot" on 4 January 1959 and brought the three men who had wintered there back to "Dumont d'Urville", arriving on 23 January. During the journey 178 gravimetric stations were occupied along the same profile as the seismic survey of 1957. Glaciological, meteorological and magnetic observations were also made.

The supply ship *Norsel* left Le Havre on 24 October 1958, carrying a relief party of twelve, led by R. Merle, and 300 tons of supplies and material. She arrived at "Dumont d'Urville" on 7 January 1959 after calling at Kerguelen. On 24 and 25 January a party was landed at Cape Denison to take magnetic measurements. *Norsel* left Terre Adélie again on 1 February. The supply operation was accompanied by a summer party consisting of P.-E. Victor, three helicopter pilots and two mechanics, led by Commandant C. Petitjean. During the summer visit the Djinn helicopters were flown for 136 hours.

On 7 January A. Prudhomme, the chief meteorologist at "Dumont d'Urville", was lost in a blizzard while taking meteorological readings, and is presumed to have been drowned.

Japan

The Japanese Antarctic Research Expedition III, 1958–59, left Tokyo on 12 November 1958 in *Soya*, which had been modified to carry aircraft. Sea ice again prevented the ship from reaching "Syowa" station so the re-supply was carried out entirely by means of two Sikorsky S-58 helicopters. Between 14 January and 5 February 1959, 58 flights were made and 57 metric tons of stores and equipment were successfully carried. The camp buildings, abandoned in February 1958, were found to be in good order and two of the fifteen sledge dogs which had to be left behind were alive and well.

The new wintering party consisted of fourteen men, including eight scientists, and is led by M. Murayama.

New Zealand

A combined gravity and magnetic survey was carried out from Dailey Islands to Granite Harbour with the assistance of air transport provided by the United States Navy. Gravity observations were made on the Dailey Islands, at Cape Chocolate, Butter Point, Spike Cape, Marble Point and Granite Harbour. Unfortunately the aircraft was damaged on landing at Cape Chocolate so ending the surveys. It had to taxi back to "McMurdo" over the sea ice. A gravity station was also established on White Island, using a Sno-cat for transport. Routine scientific observations were carried out at "Scott base" throughout the year with complete success, the last I.G.Y. observations being taken at noon on 1 January 1959. The wintering party returned to New Zealand on U.S.S. *Arneb* in January 1959.

New Zealand/United States

Routine scientific observations were carried out uneventfully throughout the year with unexpected reception of "whistlers", for which a special amplifier and antenna had been built, and the recording of a new spectral line on the auroral spectrograph.

On 9 October 1958 five United States aircraft, one Dakota and four Globemasters on their way from New Zealand to "N.A.F. McMurdo" were forced by weather to land at "Hallett" station. A week later another Globemaster, on its way to make an air-drop at "Hallett", crashed about 35 miles north of the station and six of the occupants were killed. The wintering party left on 16 January 1959 on U.S.S. *Arneb*.

Norway

On 18 April 1958 S. Helle, B. Grytøyr, L. Hochtin and T. Lunde returned from their southern sledge journey which had started on 22 November 1957. During this time they had carried out survey and glaciological work in the mountainous area between longs. 0° and 3° E. Lunde and Hochtin made another glaciological journey to the mountain region south-east of the station between 7 November and 26 January 1959. Together with their dog teams they were carried to the area by Otter aircraft of the Norsk Polarinstitutt air survey party. Scientific work continued throughout the winter at "Norway station" without incident.

The supply ship *Polarbjørn*, Captain H. Marø, left Oslo on 1 November 1958 and reached "Norway" station on 22 December, after an uneventful voyage. She carried the personnel and equipment of a Norsk Polarinstitutt air survey party, which carried out a successful photographic survey of the mountains between long. 4° 30′ W. and long. 30° 3′ E. during the 1958–59 southern summer.[1] The party consisted of Bernhard Luncke (leader) and S. Svindland, photographers; T. Winsnes, surveyor and geologist; and nine members of the Royal Norwegian Air Force under the command of Major G. Odden. There were also five replacements for "Norway" station itself; three meteorological assistants, A. Ernstsen, K. Hansen and J. P. Madsen; K. Ødegaard, radio operator; and R. Johnson, steward. Ten members of the wintering-party returned in 1959; four remained, S. Helle, H. Bjerke, J. Snuggerud and T. Vinje. *Polarbjørn* left "Norway" station on 31 January 1959.

United Kingdom (not including F.I.D.S. stations[2])

Routine scientific observations continued throughout the year at Halley Bay station. A number of short man-hauling journeys were made, the longest being about 50 miles, in order to survey the ice front in the vicinity of the station, and to study the glaciology and meteorology of the area. The supply ship *Tottan* arrived on 10 January 1959 carrying the F.I.D.S. party to take over the station from the Royal Society expedition. A storm delayed unloading, but *Tottan* left again on 16 January, and, after being beset for a week, reached the ice edge by the 25th.

United States

"*Little America V*". Between 24 March and 10 April 1958, A. P. Crary led a traverse party to mile 160 along the trail to "Byrd" station. Seismic, magnetic, gravity and glaciological observations were made at stations 20 miles apart during the return journey.

A tractor train left with supplies for "Byrd" station on 25 September and completed the 647 mile journey on 14 October. Weather delayed the outward journey but the return took only 9 days. The train consisted of 8 D-8 tractors, 14 20-ton sledges, wanigans and a Weasel equipped with a crevasse detector.

The main, Victoria Land, traverse left the station on 15 October led by A. P. Crary and consisting of six scientists with three Sno-cats and two 2½-ton sledges. T. Hatherton, chief scientist of the N.Z. I.G.Y. party, joined the traverse on 17 November.

[1] See p. 35–37. [2] See p. 46–54.

The party crossed the Ross Ice Shelf, ascended the Skelton Glacier, and travelled westward over the Victoria Land plateau along lat. 78° 4′ S. to long. 128° 3′ E. The return was made along the same track to McMurdo Sound, where the traverse of 1629 miles ended on 31 January 1959. The traverse was supported by three supply flights and a fuel depot on the plateau. Seismic, magnetic, gravity and glaciological observations were taken at intervals of about 60 miles on the Ross Ice Shelf and of 30 miles on the Victoria Land plateau. In lat. 79° 6′ S., long. 165° 3′ E., about 48 miles south of Mount Discovery, an ocean depth of 4,400 ft. (1037 m.) below the ice shelf was measured.

The S.I.P.R.E. deep drill programme, under R. H. Rangley, opened on 31 October and continued during November to a depth of 243 m. Ice deformation studies were also restarted from "Camp Michigan", Roosevelt Island, earlier in the month, under J. R. Reid, Jr.

A reconnaissance party left on 15 November to establish a trail between "Little America V" and McMurdo Sound, in connexion with the evacuation of "Little America V". The journey of 475 miles was uneventful until within 30 miles of McMurdo when a tractor, hauling two 20-ton sledges, crashed into a crevasse some 30 ft. deep. The drivers were uninjured but the equipment had to be abandoned. The party eventually reached their destination on 8 December.

A tractor train took mobile equipment to the emergency landing ground at "Little Rockford" at mile 160 on the route to "Byrd". The return journey, beginning on 29 December, took 6 days.

Two airborne traverses were carried out from the station. One led by E. C. Theil, took seismic, gravity and glaciological observations at seven stations along the 130° W. meridian between Executive Committee Range and the Harold Byrd Mountains. The second was a 2000 mile airborne magnetic profile completed along the line (*a*) "Little America V" to "Byrd", (*b*) "Byrd"—Walgreen Coast—"Getz Ice Shelf"—"Little America V", (*c*) "Little America V" to Edsel Ford Ranges and back.

"*Byrd*" *station.* A traverse party of six scientists, led by C. R. Bentley, set out on 1 November with three Sno-cats and three 2½-ton sledges. They travelled south-west along long. 130° W. to lat. 85° S., long. 127° W. and thence eastward along the northern face of the Horlick Mountains to lat. 84° 15′ S., long. 92° W., and back to "Byrd" station, arriving on 21 January 1959. The total distance covered was 917 miles. Eight supply flights were made in support of the party. Seismic, gravity, magnetic and glaciological observations were made at intervals of about 30 miles. During the reconnaissance of the Horlick Mountains, sediments were discovered overlying a granite basement with beds of coal alternating with sandstone and shale over layers of greywacke and shale. Bivalve shelves were found in the greywackes.

Between 14 February and 6 March, a party of four, led by J. Pirrit, established a fuel depot in lat. 77° 13′ S., long. 119° 51′ W. for use during the following season's operations. They then travelled west to the Executive Committee Range, where survey and geological work was done, before returning to "Byrd" station. The range, which consists of varieties of basalts overlain by a thick series of breccias and tuffs, was reported to be incorrectly sited on existing maps.

Between 8 October and 12 November 1958, 524 tons of supplies were air-dropped at "Byrd" station in 33 flights from "N.A.F. McMurdo".

"*Ellsworth*" *station.* The traverse party to "Byrd" station set out on 30 October 1958, and consisted of 6 men with 4 Sno-cats and 12 1-ton sledges, led by J. Pirrit. Seismic and glaciological observations were made from 17 points at 30-mile intervals, beginning in lat. 81° S., long. 69° 15′ W. and continuing west along the lat. 82° S. parallel. Mountains in lat. 81° 53′ S., long. 69° 20′ W. were briefly inspected and found to contain granites intrusive into gneisses superficially analogous to the

basement suites of south Victoria Land and King Edward VII Land. The part arrived at "Byrd" station on 7 January 1959 after a journey of 1250 miles.

"*Amundsen–Scott*" *South Pole station*. Owing to the enforced cancellation o the last air drop of the year, this station had some difficulty in maintaining sufficien power during the winter season. In the event, however, the power supply wa maintained throughout the year with less than two hours interruption. Betwee 8 October and 12 November 1958, 450 tons of supplies were air-dropped at th station in 30 flights.

"*Wilkes*" *station*. Regular journeys were made to supply and relieve the sub stations and to continue routine glaciological observations on Vanderford Glacie Short visits were made in March to "Browning Island" and "Wiley Island" and som survey was carried out in the islands near the station. In April a severe storm, with winds up to 130 knots, did considerable damage to buildings and equipment J. Hollin and four others carried out a glaciological traverse between 17 Octobe and 16 November. Travelling with a Sno-cat, two wanigans and a Weasel, they reached lat. 67° 20′ S., long. 111° 45′ E., a round journey of some 400 miles.

"*Naval Air Facility, McMurdo Sound*" (formerly Williams Air Operatin Facility), operated throughout the year as the base for communication with "Byrd" and "Amundsen–Scott" stations.

"*Naval Air Facility, Beardmore*". This advance weather station and emergenc landing-ground for South Pole flights was re-established in September for th summer season.

"*Naval Air Facility, Rockford*". This was planned for use as an advance weathe station and emergency landing ground for flights between McMurdo Sound an "Byrd" station. Wanigans and supplies were brought by tractor train from "Byrd" and McMurdo Sound.

Operation "*Deep Freeze IV*". This operation provided support for the final phas of the United States I.G.Y. Antarctic programme, and supplied the first phase o the U.S. Antarctic Research Programme (U.S.A.R.P.) which took over scientifi activities at the close of the I.G.Y. It was under the command of Rear-Admira G. Dufek, U.S.N. (Ret.) and, on his retirement in September 1958, of Rear-Admira D. M. Tyree. The United States Task Force 43, providing logistic support for th operation, consisted of the following units: (*a*) Ross Sea Group: Icebreakers *Glacie Staten Island* and *Northwind*, and cargo ships *Wyandot*, *Arneb*, *Nespelen* an *Chattahoochee*. (*b*) Weddell Sea Group: Icebreaker *Edisto*. (*c*) Ocean station vessel U.S.S. *Brough*, stationed between New Zealand and the Ross Sea. (*d*) Air Develop ment Squadron Six: Twenty-four aircraft of various types and sizes, both wheel and ski-equipped. (*e*) 52nd Troop Carrier Squadron, 63rd Wing: Ten Globemaster for air dropping operations over the South Pole and "Byrd" station.

Transfer of United States stations. At the end of the I.G.Y. two United State stations in Antarctica were taken over by other nations. On 4 February 195 "Wilkes" station was taken over by P. G. Law on behalf of the Australian Govern ment. Later "Ellsworth" station was handed over to the Argentine Government.

U.S.S.R.

During the southern winter of 1958 Soviet parties manned the main base "Mirnyy" "Pionerskaya", "Oazis" (leader, B. Imerekov), "Komsomol'skaya" (leade M. A. Fokin), "Vostok" (leader, V. S. Sidorov), and "Sovetskaya" (leader, V. K Babarykin). The record low temperature at the earth's surface was broken sever times, both at "Vostok" and "Sovetskaya"; the last occasion being on 25 Augus 1958, when −87·4° C. (−125·5° F.) was recorded at "Vostok".

Overland operations were started in late September, when a tractor train c

nine vehicles left "Mirnyy" for "Pionerskaya". Arriving there on 9 October, the party split into two, one group of four "Pingvin" vehicles heading southwards to explore the area between "Pionerskaya" and "Komsomol'skaya", while the other returned to "Mirnyy" for more supplies. On 23 October the main overland party left "Mirnyy", consisting of six tractors and one "Pingvin", and carrying twenty-two men. It reached "Komsomol'skaya" on 12 November and there joined up with the group of four "Pingvins", which had been doing seismic sounding and other work in the vicinity. This combined group then split in two. One party, under G. Burkhanov, took 30 tons of supplies to "Vostok" and returned to "Mirnyy" on 27 December, having completed a journey of 3000 km. The other, of five tractors, set out for "Sovetskaya", which was reached on 29 November. "Sovetskaya" had been established the preceding season at this point (lat. 78° 24′ S., long. 87° 35′ E.) which was some 600 km. short of the desired site at the Pole of Inaccessibility. Ye. I. Tolstikov, the leader of the expedition, flew into "Sovetskaya" and took over leadership of the tractor party, which left on 3 December for the Pole of Inaccessibility with four tractors. After a difficult journey, during which some men contracted mountain sickness and had to be flown back to "Mirnyy", the party reached lat. 82° 06′ S., long. 55° E. on 14 December and set up the station "Polyus Nedostupnosti" [Pole of Inaccessibility] at an altitude of 3710 m. On 19 December the first aircraft landing was made here, and Tolstikov with three others flew out to "Mirnyy". The tractor train returned to "Mirnyy" on 18 January, having covered 4300 km. in 87 days. This marked the end of the season's main overland programme.

Air operations were chiefly in support of the overland parties, but apart from this some long-range flights in IL-12 aircraft were made. The leader of the flying group, V. M. Perov, flew to Mawson on 28 September, and to McMurdo Sound, via "Sovetskaya" and the South Pole, on 24–26 October. On 12–15 December he flew to the rescue of the occupants of a Belgian aircraft which had crashed somewhere in the region of lat. 72° S., long. 27° E. After some search, the four men were found, picked up, and brought back to their base "Roi Baudouin". Perov then returned to "Mirnyy".

The two relief ships were delayed in leaving the Soviet Union. The *Ob'* reached "Mirnyy" on 30 December, and the *Mikhail Kalinin* on 21 January. The relief expedition of 100 winterers was led by A. G. Dralkin. B. A. Savel'yev was in charge of the glaciological group, V. Kh. Buynitskiy of sea ice and hydrological studies, B. Bryunelli of the geophysical group, and V. I. Shlyakhov of the meterological group. A Polish party was aboard the *Mikhail Kalinin*. Two new aircraft were brought: an IL-12 and an AN-2.

Operations in the 1959–60 season are planned to include an overland journey via "Vostok"—South Pole—"Polyus Nedostupnosti", and thence either to "Mirnyy" or to the new "Lazarev" station (see p. 64). The tractor train which will do this comprises the three new 34-ton "Khar'kovchanka" vehicles, which are supercharged and able to sleep eight, pulling six sledges and 125 tons of stores. This train left "Mirnyy" on 9 February, and on 26 February reached "Komsomol'skaya", where it wintered. All personnel were flown back to "Mirnyy" and "Komsomol'-skaya" was temporarily closed.

The stations "Sovetskaya" and "Pionerskaya" were also closed at the end of the season, but may be reopened later. "Polyus Nedostupnosti" was evacuated within a fortnight of being set up, on 26 December, but recording instruments were left and the station will act as a base for further journeys. "Vostok" was relieved by air with a new party under V. Ignatov. "Oazis" was formally handed over to Poland on 23 January. It was occupied by a party of eight Poles under W. Krzeminski between 22 and 30 January and was named "Professor B. Dobrowolski". It was then abandoned.

The ships left "Mirnyy" on 30 January, carrying Tolstikov's expedition and th Poles. The *Mikhail Kalinin* sailed straight for Europe, while the *Ob'* went t Dronning Maud Land, where a site was selected for the new station "Lazarev" o ice shelf at lat. 69° 58′ S., long. 12° 55′ E. The *Ob'* came alongside the ice edg 6 km. from the site on 14 February, and 900 tons of stores were unloaded. The statio is manned by six men under Yu. A. Kruchinin, and it formally started its programm of observations on 10 March. While the station was being built, a geological part under M. G. Ravich worked in the mountains to the south, between lat. 71° an 72° S. and long. 8° and 18° E.

NOTES

BUILDINGS AND INSTALLATIONS OF THE INTERNATIONAL GLACIOLOGICAL EXPEDITION TO GREENLAND E.G.I.G. (1957–60)

[From information supplied by Expéditions Polaires Françaises.]

The winter station of the expedition is in lat. 71° 20′ N., long. 33° 55′ W., the same site as that of the French expedition to central Greenland, 1956–57.[1] It consists of four buildings, constructed from prefabricated panels of plastic materials, and connected by means of covered passages; both buildings and passages are countersunk in the snow.

Living quarters

The two-storied living and working hut is in the form of a cylinder covered by a hemispherical cupola. The diameter is 6·6 m. and the total height is 5·8 m. The building stands on a circular wooden raft resting on the snow.

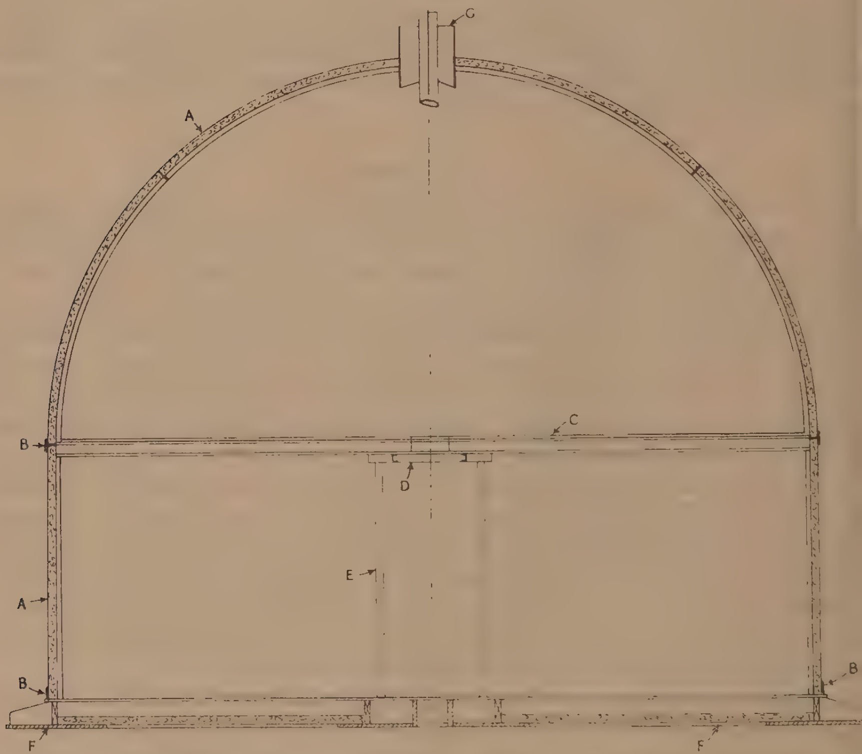
Panels. The panels (A)[2] are designed to combine maximum strength and thermal insulation with a minimum of weight and volume. Each consists of a layer of "klégécell", an insulating material completely impermeable to vapour, 50 mm. thick, glued between two layers of laminated fibreglass, each 3 mm. thick. Around the edges of the inner surface of each panel is a flange of laminated fibreglass, 10 mm. thick, and the panels are fastened together by means of pegs through these flanges. An air-tight fit between panels is obtained by means of strips of rubber shaped to lock into grooves in the ends of panels. There are eighteen panels making up the lower, or cylindrical, part of the building, and thirty six in the cupola. One of the panels in the cylindrical part contains the door. The average weight of each panel is 50 kg. The shell of the building is strengthened by means of two bands of steel (B) passing round the outside of the building, one at the level of each floor.

Interior metal framework. The floor of the upper storey is carried on a metal framework (C) at the level of the top of the cylindrical section of the hut. This framework consists of eighteen radiating tubular metal rods. The outer ends of the rods are locked in grooves in the joints between the panels of the shell, and the inner ends rest on a triangular metal plate (D), through which runs the chimney pipe. This triangular plate is supported by three metal posts (E) which transmit the weight of the upper floor to the central part of the wooden raft (F) on which the building stands. The upper floor is made of plates of sheet iron strengthened by welded metal ribs and soundproofed. A spiral metal staircase rises against the inner wall.

Base. The base, a wooden raft (F), is designed to disperse the weight of the building and to keep it in a level plane despite possible uneven snow pressure. It consists of three parts: (a) an outer ring supporting the panels of the

[1] *Polar Record*, Vol. 9, No. 61, 1959, p. 336. [2] See fig., p. 66.

building, (*b*) a central raft supporting the three upright posts of the interi
metal framework, and (*c*) eighteen radiating beams joining these two par
and supporting the lower floor of the building. There are panels of "klégécell
between these radiating beams, an arrangement which provides a doub
floor permitting the circulation of warm air between the "klégécell" and th
floor. A mechanical device under the central raft compensates for unevenne
due to unequal snow pressure, and keeps the floors level. The lower floor
made of wood with a plastic covering, and contains trap doors.



Section of "Igloo" hut used by International Glaciological Expedition to Greenla
(E.G.I.G.), 1957–60. *A*, Prefabricated panels; *B*, steel band; *C*, metal framewor
D, triangular metal plate; *E*, metal supporting posts; *F*, wooden raft; *G*, cowl.

Internal arrangements. The floor area, 60 sq.m., is arranged to provi
living space on the ground floor, and working and sleeping space on the fi
floor, for six men. In the centre of the ground floor are the heating, cooki
and water-producing units, and around these are the living room, store-roo
dark room, staircase and electric control panel. In addition to individu
rooms furnished for study and sleeping, the first floor contains a meteo
logical room and a sound-proofed radio room.

Heating. This is produced by a "Potez" warm air generator which runs on a special odourless paraffin and, on the consumption of 1 litre an hour, produces an internal temperature in the hut of 20° C. Warm air is circulated between the two layers of the double ground floor partly by convection and partly by means of a small ventilator.

Site. The hut is countersunk in the snow in a hole about 10 m. in diameter, leaving a corridor surrounding it. The roof is protected from snow by the wooden containers used for dropping supplies by parachute.

Air. Fresh air is drawn in from the corridors through pipes passing under the floor. Stale air and fumes are removed by means of a conduit passing up the centre of the building and opening to the outer air through the cowl (*G*).

Cooking. A 3-flame cooker with an oven and grill works on propane gas. The supply tank, containing 30 kg. of gas, is kept in the outside corridor and fed to the cooker by means of a brass pipe. Water is supplied from a snow tank, containing 200 litres, placed near the heating stove. Snow is melted by means of electric immersion heaters and a paraffin Aladdin lamp. A tap connects the tank with the sink and wash basin.

Outbuildings. There are three of these, similar in design and materials but differing in size: the battery storage hut measures 5 by 2 by 2 m., the emergency electric plant hut 4 by 2 by 2 m. and the glaciological hut 2 by 2 by 2 m. They are constructed from pre-fabricated panels measuring 2 by 1 m. and consisting of a layer of "klégécell" 50 mm. thick glued between a sheet of aluminium and a covering of laminated fibreglass 2 mm. thick. There is an interior wooden framework and a fibreglass door. The panels are kept rigid by means of metal frames at each end joined by four adjustable steel cables. The floors are mounted on rafts resting on the snow.

Glaciological laboratories are two simple six-sided holes 2·5 m. and 3·5 m. deep dug in the snow with roofs made from the platforms used in the dropping of heavy loads by parachute. These platforms were sandwiches of "klégécell" between skins of aluminium, measuring 3·5 m. by 1·7 m. by 0·06 m.

Corridors are dug in the snow about 3 m. deep and 1·2 m. wide to connect the buildings and supply depots. They are roofed with material used in parachute drops, and covered with snow. There are two trap doors opening to the surface of the snow, mounted on scaffolding which can be extended according to the depth of the snow.

Electrical supply. The electrical power requirements of the station were estimated to be: lighting, a permanent supply of 1 kW., radio 1 to 2 kW., an intermittent power supply of 2 to 3 kW., and a negligible amount for scientific instruments. These requirements are met with (*a*) a wind generator capable of producing 4 kW. of 110 to 160 V. potential, (*b*) a lead accumulator battery with a capacity of 470 ampères an hour, and (*c*) an emergency generator, direct current, capable of producing 4 to 5 kW., 110 to 160 V. potential.

ELECTRO-THERMAL HEATING SYSTEM FOR PROTECTION OF AIRCRAFT AND SHIPS AGAINST ICING

[Note by D. Napier and Son, Luton Airport, England.]

Aircraft are liable to have ice forming on their airframes and engines whe flying in clouds of ambient temperatures below 0° C., in which there a super-cooled drops of water. The principal danger areas are the leading edg of wings, fins and tailplanes, also engine and other air intakes, propellers an their spinners. If the ice is allowed to accumulate it will eventually impec the flight of the aircraft to such an extent as to impair its safety. For instanc ice formations will induce turbulence in the airflow over the flying surfac (wings, etc.) which reduces "lift" efficiency and causes instability in control ice accumulating on air intakes might seriously reduce the amount of a entering the intake and serious damage could result from large chunks of ic breaking away and entering the engine. Various methods have been used t prevent ice forming (anti-icing) or to dispose of it when formed (de-icing and an electro-thermal heating system, named "Spraymat", has been de veloped to perform both these functions. This system is now widely used i Great Britain, America and Europe.

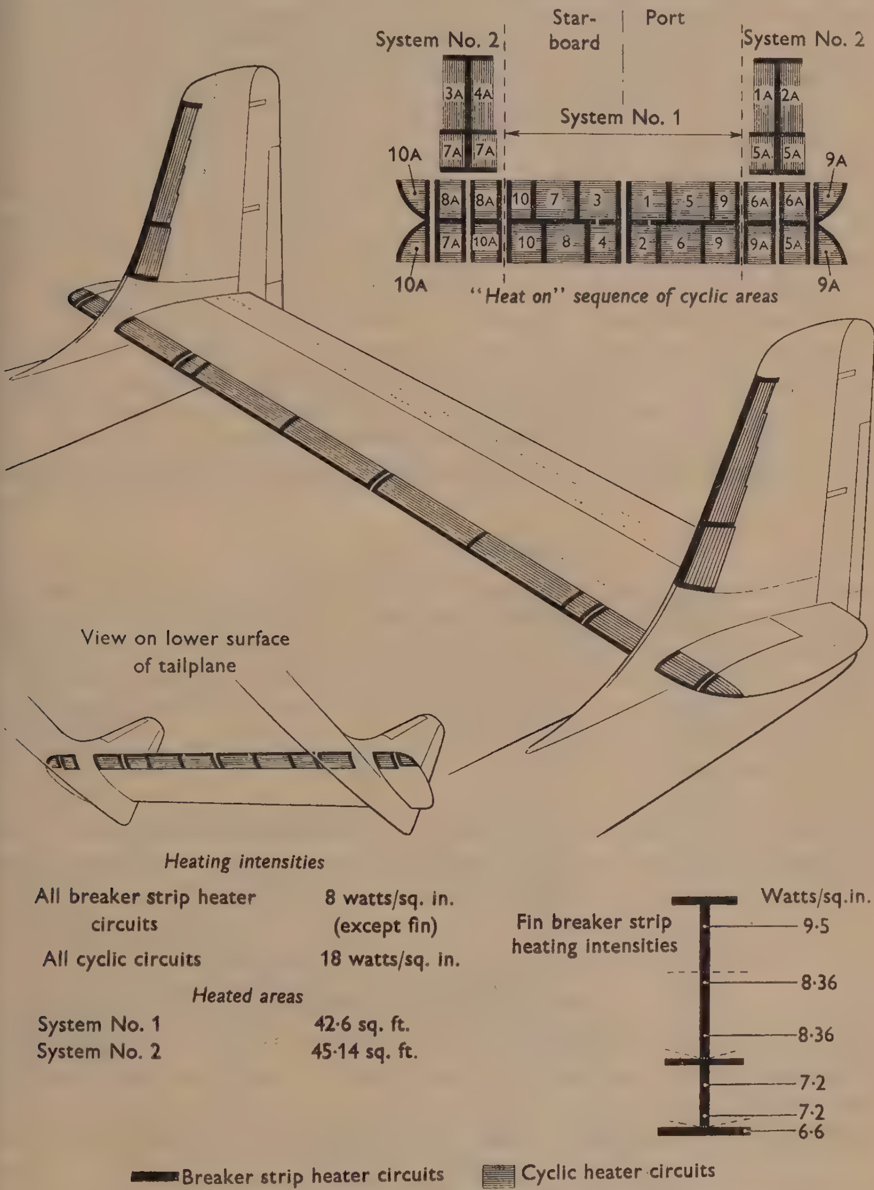
Napier "Spraymat" consists basically of a pattern of metal heating elemen sprayed on, and embedded between, two layers of insulating resin. The thre layers are built up, one after the other, directly on to the surface to be heate the thermo-setting insulating resin being applied in liquid form either b brushing or spraying, after which it is heat-cured at temperatures of 100° or less. The base insulation is reinforced with glass cloth and often, but no always, glass cloth is also incorporated in the outer insulation. The natur adhesion of the base insulating layer permanently bonds the heater mat t the component. "Spraymat" heaters can also be produced in prefabricate form by manufacturing them on special moulds, and these heaters are the bonded to the component to be heated.

The heater elements are produced by flame-spraying a suitable metal, suc as Kumanal (copper–manganese–aluminium alloy) or aluminium, to form design of parallel strips to suit the shape and heating requirements of eac individual application. Insulating gaps between the element paths are ke as narrow as possible, generally 0·05 in. (1.27 mm.), and this ensures that high percentage of the total heated area consists of actual heater elemen The element usually comprises more than 93 per cent of the total heated are

The units are immensely strong, very light, 0·3 to 0·85 lb./sq.ft. (1·46 4·12 kg./sq.m.) and wafer thin, 0·03 to 0·07 in. (0·76 to 1·78 mm.), t exact weight and thickness being dependent on the nature of the applicatio They are made to operate from voltages between 6 and 440 volts (a.c. or d. and to give continuous surface temperatures of up to about 150° C., althou substantially higher temperatures can be obtained for short periods und certain conditions.

During icing conditions certain areas, for instance engine air intakes, mu

be anti-iced, or continuously heated, but on other areas, such as tailplane leading edges, a certain amount of ice can be allowed to accumulate and subsequently shed by de-icing, or intermittent heating. In the latter system sufficient heat is applied to break the bond between the ice and aircraft structure, whereupon the ice is carried away by the airflow. Continuously heated breaker strips separate each intermittently, or cyclically, heated area, preventing ice from clinging to an adjacent area and ensuring a clean shed



General arrangement of "Spraymat" heaters on tail unit of Argosy aircraft,

during the "heat on" period. Rapid thermal response makes "Spraymat" ideal for cyclic heating systems, for instance the surface temperature of a 20 W./sq.in. heater will rise from $-20°$ to $+5°$ C. ($-4°$ to $+41°$ F.) in under 5 sec. By using the cyclic system, very considerable savings in electrical energy and alternator weight are made. The operation of the system can be made automatic by the installation of ice detectors and cyclic switches.

The heaters can be applied to all metallic and many non-metallic surfaces; they present a completely smooth finish, and are impervious to water, liquid fuels, synthetic oils, hydraulic fluids and most mild acids and alkalis.

In its standard form, "Spraymat" has exceptional resistance to rain erosion and normal abrasions, but where heaters are liable to damage from hail or runway debris at high speeds (usually a small area either side of the leading edge), an additional coating of Napier "Stoneguard" is applied over the top surface of the heater mat. "Stoneguard" is a dense compound of stainless alloy particles bonded in synthetic resin, forming a thin but practically indestructible surface coating.

The general arrangement of one "Spraymat" tail unit de-icing installation, the Armstrong Whitworth "Argosy", is illustrated in the figure. Here the heaters are arranged in two independently operated systems covering almost equal areas. Each system has ten cyclic areas and the "heat on" sequence is shown. Another tail unit installation, on the Vickers "Vanguard" airliner, has thirteen cyclic areas and the total alternator load is 34·2 kW.; if the entire installation had been continuously heated, 218 kW. would be required.

Protection of ships against icing

Icing of ships at sea is also a problem and applies particularly to fishing vessels which spend long periods in northern waters during the winter. The chief hazard is that of glaze ice formed from freezing spray being blown over the ship when the latter is below the freezing-point of sea water (28·4° F.).[1]

The largest proportion of the weight of ice carried by a dangerously iced ship is caused by water thrown on to the decks and retained by ice-choked rails and scuppers.

Tests with "Spraymat" heaters at sea indicate that an effective method of clearing ice deposits would be to have a series of heater mats which could be separately switched on in advance of a working party who could then quickly and easily remove the ice and throw it overboard.

SOVIET PLACE-NAMES IN THE ARCTIC OCEAN

[From *Pravda*, 30 June 1959.]

The Council of the Geographical Society of the U.S.S.R. [Vsesoyuznoye Geograficheskoye Obshchestvo] has confirmed for Soviet use the following place-names:

Arkticheskiy basseyn [*Arctic basin*] for the central part of the Arctic Ocean,

[1] *Polar Record*, Vol. 9, No. 58, 1958, p. 36–39.

bounded by the continental shelf. This is often called the central polar basin in English.

Khrebet Mendeleyeva [*Mendeleyev ridge*] for the submarine ridge running parallel to the Lomonosov ridge, from Ostrov Vrangelya to Ellesmere Island.

Kotlovina Nansena [*Nansen depression*] for that part of the Arctic basin on the Atlantic side of the Lomonosov ridge, and *Kotlovina Makarova* [*Makarov depression*] for that part between the Lomonosov and Mendeleyev ridges.

Vpadina "G. Sedov" [*"G. Sedov" deep*] for the deepest region (5220 m.) discovered in the Nansen depression, and *Vpadina ledoreza "Litke"* [*Icecutter "Litke" deep*] for another deep region in the same depression.

Zhelob "Leny" [*"Lena" trench*] for the trench cutting sub-meridionally across the Nansen sill in the north of the Greenland Sea.

Otmel' "Obi" [*"Ob'" bank*] for the shallow area off Nordostrundingen, at the north-east tip of Greenland.

Plato "Yermaka" [*"Yermak" plateau*] for the submarine continuation of Spitsbergen towards the north-west.

The general area covered by these place-names is one in which Soviet research has been predominant.

SOME POPULATION FIGURES FOR THE SOVIET ARCTIC, 1959

[From *Pravda*, 10 May 1959.]

The following preliminary results of the census of January 1959 relate to the Soviet Arctic:

Towns	1939	1959	1959 as % of 1939
Arkhangel'sk	251,000	256,000	102
Murmansk	119,000	226,000	189
Noril'sk	14,000	108,000	778
Petropavlovsk-Kamchatskiy	35,000	86,000	242
Yakutsk	53,000	74,000	140
Syktyvkar	24,000	64,000	263
Magadan	27,000	62,000	227
Vorkuta	—	55,000	—
Bratsk	—	51,000	—

Administrative districts	1959	Town (%)	Country (%)
Taymyrskiy Natsional'nyy Okrug	33,000	60	40
Nenetskiy Natsional'nyy Okrug	45,000	56	44
Evenkiyskiy Natsional'nyy Okrug	10,000	20	80
Koryakskiy Natsional'nyy Okrug	28,000	22	78
Chukotskiy Natsional'nyy Okrug	47,000	56	44
Khanty-Mansiyskiy Natsional'nyy Okrug	125,000	27	73
Yamalo-Nenetskiy Natsional'nyy Okrug	63,000	35	65
Kamchatskaya Oblast'	220,000	64	36
Magadanskaya Oblast'	235,000	81	19
Komi A.S.S.R.	804,000	59	41
Yakutskaya A.S.S.R.	489,000	49	51

THE NORTH-EAST ATLANTIC FISHERIES CONVENTION, 1959

A new North-East Atlantic Fisheries Convention was signed in London on 24 January 1959 by representatives of the governments of Belgium, Denmark, France, the Federal Republic of Germany, Iceland, the Republic of Ireland, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, U.S.S.R. and the United Kingdom. It was ratified by the United Kingdom in September and requires similar action by the other signatories before coming into force; it will then replace the convention signed in 1946 and finally ratified in 1953.

The principal provisions governing the North-East Atlantic Fisheries Commission established by the convention are contained in Articles 1, 6, 7, 8 and 9, and the Annex to the convention. These are as follows:

Article 1

(1) The area to which this Convention applies (hereinafter referred to as "the Convention area") shall be all waters which are situated

(*a*) within those parts of the Atlantic and Arctic Oceans and their dependent seas which lie north of 36° north latitude and between 42° west longitude and 51° east longitude, but excluding

(i) the Baltic Sea and Belts lying to the south and east of lines drawn from Hasenore Head to Gniben Point, from Korshage to Spodsbierg and from Gilbierg Head to the Kullen, and

(ii) the Mediterranean Sea and its dependent seas as far as the point of intersection of the parallel of 36° latitude and the meridian of 5° 36′ west longitude.

(*b*) within that part of the Atlantic Ocean north of 59° north latitude and between 44° west longitude and 42° west longitude.

(2) The Convention area shall be divided into regions, the boundaries of which shall be those defined in the Annex to this Convention. The regions shall be subject to such alterations as may be made in accordance with the provisions of paragraph (4) of Article 5 of this Convention.

(3) For the purposes of this Convention

(*a*) the expression "vessel" means any vessel or boat employed in fishing for sea fish or in the treatment of sea fish which is registered or owned in the territories of, or which flies the flag of, any Contracting State; and

(*b*) the expression "territories", in relation to any Contracting State, extends to

(i) any territory within or adjacent to the Convention area for whose international relations the Contracting State is responsible:

(ii) any other territory, not situated within the Convention area or adjacent to it, for whose international relations the Contracting State is responsible and for which such State shall have made known, by written declaration to the Government of the United Kingdom of Great Britain and Northern Ireland (hereinafter referred to as the Government of the United Kingdom), either at the time of signature, of ratification, or of adherence, or subsequently, that this Convention shall apply to it;

(iii) the waters within the Convention area where the Contracting State has exclusive jurisdiction over fisheries.

Article 6

(1) It shall be the duty of the Commission:

(*a*) to keep under review the fisheries in the Convention area;
(*b*) to consider, in the light of the technical information available, what measures may be required for the conservation of the fish stocks and for the rational exploitation of the fisheries in the area;
(*c*) to consider, at the request of any Contracting State, representations made to it by a State which is not a party to this Convention for the opening of negotiations on the conservation of fish stocks in the Convention area or any part thereof; and
(*d*) to make to Contracting States recommendations, based as far as practicable on the results of scientific research and investigation, with regard to any of the measures set out in Article 7 of this Convention.

(2) It shall be the duty of a Regional Committee to perform, in relation to its egion, functions of review and consideration similar to those described in paragraph) of this Article in relation to the Commission and the Convention area. A Regional ommittee may initiate proposals for measures in relation to its region and shall nsider any such proposals as may be remitted to it by the Commission.

(3) A Regional Committee may prepare draft recommendations for consideration the Commission, which may adopt any such draft recommendations, with any odifications it may consider desirable, as recommendations for the purpose of rticle 7 of this Convention.

(4) A Regional Committee may at any time appoint sub-committees to study ecific problems affecting parts of the Region and to report thereon to the Regional ommittee.

Article 7

(1) The measures relating to the objectives and purposes of this Convention which e Commission and Regional Committees may consider, and on which the Com- ission may make recommendations to the Contracting States, are

(*a*) any measures for the regulation of the size of mesh of fishing nets;
(*b*) any measures for the regulation of the size limits of fish that may be retained on board vessels, or landed, or exposed or offered for sale;
(*c*) any measures for the establishment of closed seasons;
(*d*) any measures for the establishment of closed areas;
(*e*) any measures for the regulation of fishing gear and appliances, other than regulation of the size of mesh of fishing nets;
(*f*) any measures for the improvement and the increase of marine resources, which may include artificial propagation, the transplantation of organisms and the transplantation of young.

(2) Measures for regulating the amount of total catch, or the amount of fishing 'ort in any period, or any other kinds of measures for the purpose of the conserva- n of the fish stocks in the Convention area, may be added to the measures listed paragraph (1) of this Article on a proposal adopted by not less than a two-thirds ajority of the Delegations present and voting and subsequently accepted by all ntracting States in accordance with their respective constitutional procedures.

(3) The measures provided for in paragraphs (1) and (2) of this Article may relate any or all species of sea fish and shell fish, but not to sea mammals; to any or all thods of fishing; and to any or all parts of the Convention area.

Article 8

(1) Subject to the provisions of this Article, the Contracting States undertal to give effect to any recommendation made by the Commission under Article 7 this Convention and adopted by not less than a two-thirds majority of the Delegatio present and voting.

(2) Any Contracting State may, within ninety days of the date of notice of recommendation to which paragraph (1) of this article applies, object to it and that event shall not be under obligation to give effect to the recommendation.

(3) In the event of an objection being made within the ninety-day period, ar other Contracting State may similarly object at any time within a further period sixty days, or within thirty days after receiving notice of an objection by anoth Contracting State made within the further period of sixty days.

(4) If objections to a recommendation are made by three or more of the Co tracting States, all the other Contracting States shall be relieved forthwith of ar obligation to give effect to that recommendation but any or all of them may neve theless agree among themselves to give effect to it.

(5) Any Contracting State which has objected to a recommendation may at ar time withdraw that objection and shall then, subject to the provisions of paragra (4) of this Article, give effect to the recommendation within ninety days, or as fro the date determined by the Commission under Article 9 of this Convention, whic ever is the later.

(6) The Commission shall notify each Contracting State immediately upo receipt of each objection and withdrawal.

Article 9

Any recommendations to which paragraph (1) of Article 8 of this Conventi applies shall, subject to the provisions of that Article, become binding on the Co tracting States from the date determined by the Commission, which shall not before the period for objection provided in Article 8 has elapsed.

Annex

The regions provided for by Article 1 of this Convention shall be as follows:

Region 1—The part of the Convention area bounded on the south by a li running from a point 59° north latitude 44° west longitude due east to t meridian of 42° west longitude; thence due south to the parallel of 48° nor latitude; thence due east to the meridian of 18° west longitude; thence due nor to the parallel of 60° north latitude; thence due east to the meridian of 5° we longitude; thence due north to the parallel of 60° 30′ north latitude; then due east to the meridian of 4° west longitude; thence due north to the parallel 62° north latitude; thence due east to the coast of Norway; thence north a east along the coast of Norway and along the coast of the Union of Sov Socialist Republics as far as the meridian of 51° east longitude.

Region 2—The part of the Convention area not covered by Region 1 and nor of 48° north latitude.

Region 3—The part of the Convention area between 36° and 48° north latitu

BRITISH SYMPOSIUM ON POLAR MEDICINE, 1959

3y R. Goldsmith, Division of Human Physiology, National Institute for Medical Research ondon.]

.t a meeting held at the National Institute for Medical Research in Hampstead esearch work accomplished in the polar regions was reviewed and the future f this type of work discussed. Over 30 people connected with polar research ere present, including 20 doctors with experience in the Arctic or Antarctic, ne majority of whom had been medical officers with the Falkland Islands ependencies Survey.

The morning session was devoted to review of past work. Dr O. G. Edholm, lead of the Division of Human Physiology of the National Institute for ledical Research (which has for some years been responsible for giving uidance to prospective medical officers) was in the chair. Dr H. E. Lewis British North Greenland Expedition, 1952–54) reviewed the recent history of ritish physiological research in polar regions. He pointed out how the rganization of the work has become centralized under the wing of the Division f Human Physiology. Much of the earlier work had been fragmentary, not ecause of lack of skill but rather, perhaps, because of lack of a central neme running through it. He pointed out how, with a continuing programme f observations, numerous polar legends had been examined and put to the est. Dr J. P. Masterton (British North Greenland Expedition, 1952–54) gave n account of how a number of casual observations and well-known facts had d to some well-instrumented experiments into energy expenditure and food ntake in cold regions. From the fact that men in the cold have a high fat ntake and that huskies eat human faeces, experiments and further observations d to a number of conclusions: that in spite of fat intakes of almost 300 g. day men absorb virtually all of it, leaving the coprophagic huskies no utritional value; that men expended very large amounts of energy, 4500– 000 calories per day, while travelling with dog-sledges, and even while at neir base camp performing routine duties energy expenditure of the order of 900 calories per day were usual. Dr A. Rogers (Trans-Antarctic Expedition, 957–58) continued this work. Measurements made with the IMP apparatus onfirmed earlier estimations of the very high energy output of men at base. lajor J. M. Adam, who took part in the Anglo-American Antarctic Physio- gical Expedition of 1958, suggested, from measurements made on men of the rans-Antarctic Expedition during the last few days of the trans-continental urney, that, although travel with vehicles was obviously less strenuous, the aily energy output actually approached that of sledging because of the longer ay.

Dr L. G. C. Pugh described experiments performed in the Antarctic with e Anglo-American Antarctic Physiological Expedition to measure effects of lar radiation on man. He found that in spite of the low altitude of the sun, en travelling during the summer could gain more than 300 calories/m.^{2}/hr., hich would be the same as raising the ambient temperature by 10° C. The in under desert conditions is of the order of only 240 calories/m.^{2}/hr,

Dr H. T. Wyatt (F.I.D.S.) described the persistence of cold diuresis througho a year's stay in the Antarctic, and also gave a description of trials on a ne dog ration. Dr J. Graham (F.I.D.S.), following up observations made c the British North Greenland Expedition and the Trans-Antarctic Exped tion on sleep rhythm, showed that even in this remote area of the world soci pressure partially determined the length of nightly sleep, i.e. about 8 hou in 24, and that when some of this pressure was released by the departure the base leader the average nightly sleep went up to above 9 hours. He coul find no clear correlation between length of sleep and the previous day's worl

The afternoon discussion on the future of medical and biological researc in polar regions was initiated by Sir Vivian Fuchs, Scientific Director c F.I.D.S. He admitted, on seeing the size of the meeting, that "physiolog had come to stay in the Antarctic" but pointed out that up till now it ha naturally received a rather low priority. He stressed the well-known difficult of persuading subjects to co-operate in what might sometimes be rath unpleasant experiments. The suggestion that for better results it would b advisable to have two medical men at one station was obviously sound. Th meeting was heartened too by his suggestion that a physiological station i the Antarctic might be feasible. Many problems of cold climate physiolog could be investigated at such a station, and might indeed be as useful in th field as the early high altitude expeditions in the Andes were to respiratio physiology.

Sir Raymond Priestley, one of the veterans of polar exploration, suggeste that since his day the psychological problems have changed considerabl where there was once complete isolation and real hardship there was no radio and relative comfort, but there is still the problem of living in consta close contact with one another. There is much to be learnt from intelligen discreet observation.

The discussion touched on other suitable topics for investigation; f example, it was felt that the time had come to observe the reaction of wome as well as men to a polar environment, and that investigation into the adapt tion of the local fauna would be of considerable value.

The papers and the discussions gave some hint of the interest and furth possibilities for medical research in the polar regions. The medical professi ought to be no less forward in making their claim in this fascinating field human endeavour than other scientists have been.

SOVIET ATOMIC ICEBREAKER, *LENIN*

[By Terence Armstrong.]

The Soviet icebreaker *Lenin*, which is the first surface ship to employ atom power, left Leningrad on her maiden voyage into the Baltic on 15 Septemb 1959. Some descriptive details were given in an earlier issue.[1] Furth information was made available by *Pravda* on 13 September and Mosco

[1] See *Polar Record*, Vol. 9, No. 59, 1958, p. 154.

Radio on 15 September. The ship's three reactors, one of which is normally in reserve, provide steam for turbines which drive generators to produce current for the electric motors which turn the propellers. There are three propellers, all aft, with the centre one twice as powerful as the others. Two helicopters are carried, one of which has a television camera to transmit ice information to the bridge. The power developed by the engines, 44,000 h.p., is double that of the next biggest icebreaker afloat, the American *Glacier*. It is expected that the ship will be able to maintain a steady speed of two knots through ice 2 m. thick. This implies, of course, ability to break much thicker ice when not maintaining a steady speed of advance.

The ship is designed primarily for work in the Arctic. She will be used, in the same way as eight or so of the next most powerful icebreakers in Soviet service, to escort shipping along the Northern Sea Route, where the captain thinks she will be able almost to double the length of the navigation season. It is clearly also hoped that she will be able to get to places no other icebreaker has yet reached. The Minister of the Merchant Fleet, V. Bakayev, who is responsible for the ship, has spoken of opening up new routes which might prove better than the presently used channels. He probably has in mind the "northern variants" of the Northern Sea Route, passing north of the island groups. A. F. Treshnikov, a leading Arctic and Antarctic explorer, has expressed the hope that the ship would soon reach the North Pole. He sees her as an aid to explorers in reaching places unattainable by aircraft, submarine or drifting station.

An attempt to reach the North Pole is certainly to be expected, for this was the dream of Admiral S. O. Makarov, who first realized the idea of a polar icebreaker when he had the *Yermak* built in 1898. Such a voyage might be possible, even though the average thickness of the ice will certainly exceed 2 m., and success would naturally open up tremendous possibilities. But there are limitations to which even the *Lenin* is likely to be subject: the voyage would have to be in summer, since the difference in navigating very close pack ice of nine-tenths cover and consolidated pack ice of ten-tenths is great; further, even if the North Pole were reached, this would not imply ability to reach any part of the Arctic Ocean, for the evidence of the Soviet drifting stations shows that the character of the pack ice changes from place to place; and lastly, it is unlikely that the *Lenin* could escort any other ship or ships.

From the point of view of transporting scientists and instruments to otherwise inaccessible places, the *Lenin* will no doubt have the advantage over aircraft, submarines and drifting stations. But this will be not so much the result of her ability to reach such places in the ice—after all, there are not so very many pack ice areas that are both too rough for aircraft to land and yet are remote from an open water pool large enough for a submarine to surface—as of her freight-carrying qualities. She can not only carry more than either aircraft or submarine, but, more important, can carry bulkier objects. This could be especially valuable in the Antarctic.

Whether the *Lenin* will be an economic proposition or not will depend on the amount of extra freight which her presence will permit to be transported

on the Northern Sea Route. Its total freight turnover is not known with an accuracy, and operating costs are not known at all, so the value of a doublin of the length of the season (if that is in fact possible) cannot be calculate It is likely, however, that the *Lenin* will be nearer to being an economic shi than the atomic freighter *Savannah* launched in the United States in 1959.

CHILEAN POLAR TRANSPORT VESSEL, *PILOTO PARDO*

[From information supplied by N.V. Haarlemsche Scheepsbouw-Maatschappÿ.]

The single-screw passenger and cargo vessel, *Piloto Pardo*, was built for th Chilean Navy by N.V. Haarlemsche Scheepsbouw-Maatschappÿ, Harlem Holland, for use in Antarctic waters, and sailed for Chile in April 1959. Th vessel conforms to the requirements of the Lloyd's Register of Shippin "strengthened for navigation in ice"[1] and of the Finnish Ice Class A1.

Dimensions are: thickness of plating of the hull 20 mm., length overal 81·6 m., breadth moulded 11·9 m., draught 4·6 m., deadweight tonnag 1200 tons, cargo capacity 1845 cu.m. Propulsion is by means of three diese electric engines, each developing 770 h.p. at 750 r.p.m., and capable o attaining a speed of 14 knots. A helicopter deck and shelter are built in th superstructure. The vessel has an icebreaker bow, and can be controlled fron the crow's nest for navigation in ice. There is accommodation for 44 passenger and a crew of 60, and provision is made for medical and dental surgeries a laboratory and a dark room.

[1] *Polar Record*, Vol. 8, No. 56, 1957, p. 426–28.

The atomic ice-breaker *Lenin*

Photograph by N. Naumenkov and I. Baranov

(*Facing p. 78*)

Chilean polar transport vessel *Piloto Pardo*

S.C.A.R. BULLETIN

No. 4, *January* 1960

Programmes for 1959–60

Norway. No expedition is to be sent to Antarctica at the end of 1959. Personnel and equipment will be returned from "Norway" station early in 1960 in the *Polarbjørn*.

South Africa. An expedition left for Dronning Maud Land in November 1959 to take over "Norway" station on the coast of Antarctica. The wintering party will consist of seven scientists and three technicians under the leadership of J. J. la Grange, who was a member of the Trans-Antarctic Expedition, 1955–58. The scientific programme will include meteorology (surface and upper air), auroral physics, geology, geomagnetism, radiation and physiology.

United States. An attempt will be made to penetrate the Bellingshausen Sea during the coming season. Two icebreakers, U.S.S. *Glacier* and *Burton Island*, are expected to arrive in the area in February 1960 to take part in the operation. Both ships are equipped with helicopters for reconnaissance and scientific work. The scientific programme is to include oceanography, cartography, geology, biology and glaciology.

New scientific stations in Antarctica, 1959

The Soviet station "Lazarev" was established on 10 March 1959 in lat. 69° 58′ S., long. 12° 55·4′ E. on Prinsesse Astrid Kyst, Dronning Maud Land. It is situated on the ice shelf 10 km. from the coast, in an area where the ice shelf extends northwards for about 100 km.

The station consists of three main buildings connected by covered passages. The largest building, with an area of 80 sq.m., is divided into compartments for radio, meteorology, a dark-room, living-room and three bedrooms. The power-house nearby contains two 26 kW. generators which are used alternately. There is also a store. The meteorological laboratory is 50 m. away from these buildings, and 120 m. away are emergency living-quarters, power station and radio hut. A tent depot was set up 9 km. away containing reserve supplies of food and fuel. There is a runway for ski-equipped aircraft nearby.

Personnel consist of a geographer (Yu. A. Kruchinin, also the leader), two meteorologists, a radio-operator, doctor and two mechanics. The scientific programme includes meteorology (surface and upper air), glaciology, geography and magnetism.

As a result of the first 6 months' observations, the following information has been gained. The direction of the prevailing wind is easterly, and the average velocity is 15·3 m./sec. rising, during a 12-day period of blizzards in April, to an average of 21·3 m./sec., and a maximum of more than 60 m./sec. The mean temperature was −18·5° C., with a minimum of −46·7° C. on

3 September. The average annual temperature was estimated at abo
−15° C. Annual accumulation of snow is 1 m. and the mean surface densit
is 0·3. The depth of the sea near the station is 700 m.

The Soviet station at the Antarctic Pole of Inaccessibility [Polyus Ned
stupnosti] was established on 14 December 1958 in lat. 82° 06′ S., lon
54° 58′ E., 2100 km. from "Mirnyy" and at an altitude of 3720 m. Th
object of the station was to form a temporary base for programmes of scientif
observations and an auxiliary base for inland traverses; there is no intentio
that it should be manned throughout the year.

During the period 14 to 26 December 1958 observations were carried ou
in the disciplines of meteorology, glaciology, seismology, magnetism an
gravity. Observations of air temperature, pressure and humidity, temperatur
of snow surface, wind direction and velocity, cloudiness, atmospheric pheno
mena and visibility were made four times daily, as were actinometric observa
tions of total, dispersed, and reflected radiation of the sun, and of radiation
balance. Glaciological work consisted of temperature recordings of the néve
from the surface down to 50 mm. as well as in small pits, determination o
ice thickness by seismic soundings and of the physical properties of the néve
by means of ultrasonic techniques. Magnetic observations were made a
frequent intervals to determine the horizontal and vertical components o
the magnetic field of the earth.

As a result of these observations the following information was gained about
the area of the Pole of Inaccessibility: meteorological conditions were typica
for inland areas in "East Antarctica" and differ only slightly, at least i
summer, from those around "Sovetskaya" and "Vostok". Cyclones, however
were heralded by more typical cyclonic disturbances than in the area aroun
"Sovetskaya". Heavy deposits of hoarfrost of 8 cm. in thickness result in a
very soft snow surface of densities of only 0·11 to 0·14 g. per cu.cm. Ai
temperature varied from −37·4° to −27·5° C., the maximum temperatur
was usually at mid-day and the minimum in the early morning. Temperature
in the 50 m. deep bore-hole at the zero amplitude level were used to determin
the mean annual air temperature, which is about −56·8° C. Fluctuations o
atmospheric pressure were within the limits of 603·8 to 613·9 mb. The mea
relative humidity was 56 per cent. The prevailing wind direction was northern
and the average velocity was 3·6 m./sec. Clouds were mainly cirrus. Bedrock
is 770 m. above sea-level, and the thickness of the ice cover 2950 m., includin
a névé layer of 140 m. These observations formed a final link in the chain o
observations carried out from the Davis Sea to the Pole of Inaccessibility.

A combined living and working hut was transported from "Mirnyy" o
a sledge. With an area of 20 sq.m., it is divided into two compartments
The one provides living accommodation for four men and includes an electricall
operated kitchen. The other part is a workshop containing a gasoline-drive
drill and a 12 kW. generator, meteorological instruments and a 70 W. radio
An airstrip, 30 m. wide and 1200 m. long, was made near the hut. The statio
was temporarily closed on 26 December, when 5 months' supply of provision
for four men and some 7 tons of fuel and lubricants were left in the hut.

Soviet station "Polyus Nedostupnosti", December 1958

Photograph by V. K. Barbarikin

(*Facing p.* 80)

"Wilkes" station, Vincennes Bay, Wilkes Land, February 1959

Antarctic climatological studies

An Antarctic climatological study, similar to those published by the United Kingdom and South Africa, is in preparation by Argentina.

S.C.A.R. Bulletin

S.C.A.R. Bulletin is now reproduced in Spanish by the Instituto Antártico Argentino.

Antarctic radio communications

By A. H. Sheffield[1]

In former years expeditions sailing for the Antarctic lost all contact with the world after their last port of call and were not heard of again, sometimes for years, until their return to civilization. Nowadays they are in constant radio contact and can send back reports to their home countries every day, while members of expeditions can even be connected via the public telephone service to their own homes. Veterans of earlier expeditions are sometimes heard to disparage this regular misuse of radio service, but there can be no doubt of the value and importance of effective communications, not only for safety of life but for the effective prosecution of the scientific objectives of the modern expedition.

This was realized in the early planning stages of the Antarctic programme for the International Geophysical Year, and an International Working Group on Antarctic radio communication was set up, representing each of the twelve nations participating in that programme and the World Meteorological Organization. The first task of this Working Group was to prepare a plan for the collection and dissemination of weather and other messages, and for this purpose a network of seven mother and forty daughter stations was arranged. The plan provided for daughter stations to transmit reports to their mother stations at fixed times; and the mother stations passed on the collected information to the Antarctic Weather Central at "Little America V" or "N.A.F. McMurdo". Arrangements were made for relays and duplicate reception in case of difficult working conditions, and the Weather Central broadcast meteorological information five times daily throughout the I.G.Y.

A major difficulty in radio communication nowadays is that the frequency spectrum is overcrowded. Too many radio transmitters are using too few frequencies. For the Antarctic programme provision had to be made not only for local transmissions between mother and daughter stations, and between those stations, mobile parties, and temporary bases, but for long distance communication to the home countries of the various expeditions, and for their ships and aircraft. Radio beacons were set up here and there, and provision has to be made for amateur radio operators at many bases. It was decided at an early stage that frequencies for the new stations would be sought in the internationally recognized frequency bands, and the International

[1] Chairman of Working Group on Communications.

Frequency Registration Board co-operated in clearance of the frequencies put forward by the Working Group, which in effect had constituted itself as a temporary frequency clearing agency for the Antarctic. When the I.G.Y. began, over 60 radio stations were operating in the Antarctic, using more than 1000 separate frequencies. Each frequency had to be checked to ensure that there was no duplication, or likelihood of interference with other stations. Where there appeared to be a danger of interference suggestions for other frequencies were made. In the event, no complaints of interference between Antarctic stations, or interference with other traffic, were received by the Working Group during the whole period of the I.G.Y.

All available information about the Antarctic radio network was collated in the *International Geophysical Year 1957–58; Antarctic Radio Communication Manual*, Pergamon Press, London, 1956, and a revised edition was published in 1957, in time for the beginning of the I.G.Y. The manual included lists of bases with their geographical positions, radio frequencies to be used, information on procedures, time signals, standard frequency signals, call signs; schedules of meteorological broadcasts, and other information likely to be of use to radio operators.

When it was decided to continue Antarctic research under the auspices of S.C.A.R., the I.G.Y. plan for collection of meteorological information was reviewed. In place of the Weather Central at "Little America V" an International Antarctic Analysis Centre was established by the Australian Bureau of Meteorology in Melbourne and began operations in February 1959. The I.G.Y. Working Group on Radio Communications was succeeded by a similar body under S.C.A.R. and, although the Group has not yet met, the members have been in correspondence with each other to revise their plans as necessary. The I.G.Y. network was taken as a basis for the S.C.A.R. system, but experiments are being carried out to discover better methods of passing information to the new Analysis Centre. These include arrangements for collecting and relaying all South American data to "N.A.F. McMurdo" through "Ellsworth", where radio teletype equipment is being installed. "Ellsworth" has been taken over from the United States by Argentina, and radio tests between Buenos Aires and "Ellsworth", and between "Ellsworth" and "N.A.F. McMurdo", are about to be made.[1] The aerials at "N.A.F. McMurdo" are to be rearranged to provide for direct transmission to Melbourne instead of passing traffic through Musick Point, New Zealand, and it is hoped this change will improve the reliability of the link between those two stations.

The Antarctic Whaling Ship collective broadcast from Pretoria was generally being received satisfactorily in Melbourne earlier in 1959, but it is intended to augment this by the use of the cable, or by a direct point-to-point radio transmission over the Pretoria to Perth link, which should give reliable reception throughout the year.

Transmissions from "Mirnyy" are generally received clearly in Melbourne, as are those from Mawson and "Wilkes", which include data collected from their daughter stations.

[1] See p. 87.

Reports from the Falkland Islands Dependencies are broadcast by Port tanley Radio three times daily, two of these transmissions being picked up y "N.A.F. McMurdo", and there is a point-to-point transmission between tanley and "N.A.F. McMurdo" daily at 19.00 hours to complete the remainng synoptic information, and to check on any data missed in the broadcasts.

Although there has been considerable progress in rearrangement of the ntarctic radio network, finality has not yet been reached, and it is clear that urther tests will have to be conducted in order to ensure that, within the imitations imposed by conditions in this difficult area, the radio links are as ffective as possible.

In Antarctic radio many problems confront engineers and operators. erial supporting masts and towers must be designed to withstand high wind ressures, and heavy snow deposits. Equipment is subjected to stresses and trains by wide variations of temperature. Auroral absorption problems are onsiderable and interruptions are caused by geomagnetic and ionospheric listurbances. On the whole, however, atmospheric interference due to the lizzards which are so frequent in the Antarctic did not cause significant nterruption of traffic during the I.G.Y., and it is hoped that similar good ortune will attend the operations of the S.C.A.R. stations.

During the I.G.Y. meteorological information was sometimes late in arriving t the Weather Central. Attempts were made to discover the causes of such lelays and to apply remedies, because, although delay can be accepted where he information is for climatological or research purposes, it could be dangerous vhere it is to be used by aircraft crews in flight planning. There is no firm vidence that, given properly planned radio stations, regular and reliable ommunication between them should not have been possible, and it appears hat some of the difficulties were attributable to operational procedure. It annot be too strongly emphasized that, apart from the occasional poor ropagation conditions, it is the radio operator who can ensure success—by areful selection of the optimum frequency for the time of day, accurate uning and regular maintenance of equipment, and co-operation with his olleagues at the other end of the circuit. In the report on I.G.Y. operations y Dr Ward, the Australian representative on the S.C.A.R. Radio Working roup, he referred to satisfactory communications between Australia and the ntarctic by radio amateurs using powers only of the order of 50 W. on single ideband transmitters, which suggest that effective links for the S.C.A.R. proramme will be provided in due course. It is hoped that the Antarctic Symposium o be held in Buenos Aires in November 1959 will give an opportunity for disussion of current planning and to produce suggestions for improvements.

I have referred above to the importance of the radio operator in ensuring ffective communications, and I should like to take this opportunity of aying a tribute to all those who have been entrusted with the responsibility f operating the Antarctic radio stations during the past three years. Operation n Antarctic conditions is an exacting task, particularly where traffic is heavy nd long hours at the key are necessary. Spare parts are not always available nd the Antarctic radio operator, in addition to taking his share of the

domestic duties of the base, often has to act as his own mechanic, fabricatin
spares for his equipment from the most unlikely material. As well as bein
skilled as an operator and mechanic, the operator at a small base mus
therefore be an enthusiast.

The next few months will be occupied in reviewing the present communica
tions network, on the lines described above; but in a programme of thi
nature all concerned must be ready to make alterations to keep pace wit
changing conditions, and only by constant attention to the problem will i
prove possible to perfect the network so that collection and dissemination o
meteorological and other data will be complete and effected with the minimur
of delay. Close co-operation by the participating countries will be the keynote
and the experience of the I.G.Y. shows that this will be readily available.

Recommendations on procedures for visual auroral observation in Antarctica

By O. Schneider[1]

(1) *Introduction.* These recommendations were drawn up by the S.C.A.R
reporter for upper atmosphere physics in consultation with individual aurora
workers in S.C.A.R. countries, as directed by a resolution of the third S.C.A.R
meeting, Canberra, 2–6 March 1959. It is the purpose of these recommendation
to render visual auroral data more useful as a means for supplementing all
sky camera observations with the objective of drawing synoptic maps o
auroras. Messrs D. Barbier, C. W. Gartlein, M. Huruhata, F. J. Jacka
J. Paton, A. H. Shapley, I. L. Thomsen and A. M. van Wijk kindly sen
suggestions, comments and other information.

(2) *General instructions.* No essential changes seem to have been introduce
by the different national Antarctic agencies in their present observing pro
cedures and instructions as compared to those used during the I.G.Y. It i
therefore recommended to adopt the chapter on "Visual Auroral Observation"
by S. Chapman, in the *I.G.Y. Manual* as a basic guide (*Annals of the I.G.Y*
vol. IV, part II, pages 41–103; Pergamon Press, London, New York, Paris
1957); Antarctic observations, however, should in any case be more complet
than the "minimum programme" described there in section 2 (pages 51–56

(3) *Observers.* Traverse parties, supply and relief expeditions, etc., should b
encouraged to participate in the visual auroral programmes.

(4) *Observing times.* A desirable maximum programme will comprise a
observation every quarter hour during the whole period of darkness, on a
days. Possible intermediate plans would be hourly or tri-hourly, and a min
mum plan would call for observations only at the regular weather observin
times. World Days and Alerts (see section 9) offer an opportunity for intensifie
programmes to those observers or parties who would normally observe onl
on a limited schedule. Whichever the particular scheme adopted, it
important for the eventual synoptic processing of the data that, wheneve
observations are made, they should be on the hour and quarter hour o
Universal Time.

[1] S.C.A.R. reporter on Upper Atmosphere Physics.

(5) *Description and quantitative features.* (*a*) *Auroral forms.* The full auroral lassification as given in the international *Photographic Atlas of Auroral Forms* nd in the *I.G.Y. Manual* is recommended. Intermediate forms and sunlit ays should be carefully recorded, but no particular symbols are suggested or the time being.

(*b*) *Brightness.* The four-degree scale should be used.

(*c*) *Colours.* It is suggested that observers should describe colours in terms f their own choice.

(*d*) *Angular measurements.* Important features to be measured are: on uroral forms with sharp lower border, the apparent highest point (elevation nd bearing), the turning points (if "hooked" form), bearings to extremities, nd suitable intermediate points; lower and upper limits of rays (of each ortion if broken); radiation point of coronas; upper and lower limits, s well as lateral extremities, of bands and surfaces. Elevation should be etermined with special care when the point measured is low over the horizon.

(*e*) *Events.* The following events are of interest, and whenever possible hould be recorded in addition to quarter-hourly entries, giving their time to he nearest minute: sudden appearance or vanishing of aurora; change of uiet homogeneous into active rayed forms, or *vice versa*; onset and cessation f flaming or pulsation; movements, either of the aurora as a whole or of istinct features, giving times, direction, sense, and apparent speed.

(6) *Auroral logs.* Date and time of individual entries should be stated in Jniversal Time. If double date according to local standard time be specified, his should be clearly stated. Logs should also contain entries on observing onditions (cloud, moon, twilight, etc.). Impossibility of deciding whether urora is present should be stated as such; the assertion "No aurora" should e used most carefully. Different entries should be made for "No observation nade" and "Observation made but no aurora present". A distinction should lso be made between "Beginning (or end) of display actually witnessed" nd "Aurora present at beginning (or end) of observation".

(7) *Plots.* The use of sky blanks as plotting forms is strongly recommended.

(8) *Analysis sheets.* Lists with quarter-hourly entries summarizing the main eatures of auroral displays are considered useful for later synoptic processing f data.

(9) *World Days.* Fixed-date World Days of different kinds are listed below the "International Geophysical Calendar 1960". In addition, *Alerts* (some f them world-wide; others regional, called "Advance Alerts") as well as *pecial World Interval* (SWI) will be declared following specified geophysical solar events. Auroral observers will pay special attention to the particular ype of Alerts called "Auroral Alerts", but intensified auroral observing hedules are also justified in the case of Magnetic Storm Alerts, and during WI's. Some types of warnings will not distinguish between the different nds of Alerts, and observers who get only this simplified information should art an intensified programme in any case. Alert warnings and SWI declara-ons will be released by the World Warning Agency at 16.00 U.T. of the days ncerned, and intensified observational activity should be started upon

receipt in the field, and continued for 24 hours as a minimum; new messag may declare continuation of an SWI, usually after 2 or 3 days. World Warnin Agency, AGIWARN, is at Central Radio Propagation Laboratory, Box 17 Ft. Belvoir, Va., U.S.A. Regional warning centres are at Canberra (Australia NIZMIR (U.S.S.R.) and Kokubunji (Japan). AGIWARN will also act as regional centre, and coded messages will be broadcast by WWV and WWVE

(10) *International Geophysical Calendar 1960.* Regular World Days (highe priority in italic): Jan. 12, *13*, 14; Feb. 16, *17*, 18; Mar. 15, *16*, 17; April 1 *20*, 21; May 17, *18*, 19; June 14, *15*, 16; July 12, *13*, 14; Aug. 9, *10*, 1 Sept. 20, *21*, 22; Oct. 18, *19*, 20; Nov. 15, *16*, 17; Dec. 13, *14*, 15; 196 Jan. 17, *18*, 19. Regular World Intervals: March 15–24; June 14–23; Sep 13–22; Dec. 13–22. World Meteorological Intervals: same as before, pl 1960 Jan. 11–20. Special Days: Jan. 4 (meteors); Mar. 27 (solar eclipse April 21, 22 (meteors); May 4, 5 (meteors); July 28, 29, 30 (meteors); Aug. 1 11, 12, 13 (meteors); Sept. 16–22 (Provisional International Rocket Wee dates to be confirmed by COSPAR); Sept. 20 (solar eclipse); Oct. 19, 20, (meteors); Nov. 16 (meteors); Dec. 12, 13, 14, 22 (meteors).

International Antarctic Analysis Centre

By W. J. Gibbs[1]

The International Antarctic Analysis Centre is operating at 468 Lonsda Street, Melbourne, Australia. Equipment of the Centre includes: (*a*) a Ozalid photocopying machine, (*b*) three teletype machines, over which a incoming reports are received, and (*c*) a facsimile receiver unit, over whic all the analysed charts and data from the Central Analysis Office of t Bureau of Meteorology are received.

Through the good offices of Dr H. Wexler, the United States I.G.Y. Nation Committee donated the library from the "Little America V" Weather Centr to the I.A.A.C.

The Commonwealth Division of National Mapping has constructed a ne base synoptic chart which will be used in future for routine analysis in t Centre.

The programme of analysis originally proposed was : (*a*) surface synopt analysis of the southern hemisphere south of lat. 30° S. twice daily (at 00. and 12.00 G.M.T.), and (*b*) synoptic analysis for 700, 500 and 300 mb. c. surfaces for the above area at least once daily (00.00 G.M.T.), with probab additional synoptic analysis for these surfaces for the Antarctic area (sou of lat. 60° S.) at a supplementary hour (12.00 G.M.T.). However, with t present professional staff, the programme is confined to: (*a*) analysis twi daily of the 700, 500 and 300 mb. constant pressure charts over the Antarct continent and adjacent islands, (*b*) daily preparation of coded statemen (WMO code FM 45) on the 00.00 G.M.T. analysis released 30 hours after t synoptic hour, (*c*) subsequent re-analysis of charts following the entry

[1] S.C.A.R. reporter on Meteorology.

delayed data, and (*d*) microfilming the re-analysed charts seven days after the close of the month.

H. R. Phillpot of the Bureau of Meteorology, and Meteorologist in Charge of the I.A.A.C., began duty in January 1959, and was joined by K. T. Morley, Senior Meteorologist of the Bureau of Meteorology, in February. Mr Morley worked in the Weather Central at "Little America V" station during 1958. T. I. Gray of the U.S. Weather Bureau, and formerly Officer in Charge of the Weather Central, "Little America V", joined the I.A.A.C. at the end of June 1959, and Lt.-Cdr. J. Timbs, a meteorologist of the Royal Australian Navy, joined early in August. After a brief period while Lt.-Cdr. Timbs was becoming familiar with the duties and requirements of his position, Mr Morley returned to duty with the Central Analysis Office of the Bureau. The Bureau had undertaken to provide only one meteorologist to the Centre, but attached Mr Morley in addition to Mr Phillpot in the early stages in order to facilitate the establishment of the new Centre. There are also ten assistants and an observer in charge.

Microfilmed copies have been made of the surface, 700, 500 and 300 mb. charts and of plotted cross-section diagrams for all Antarctic and sub-Antarctic observing points, beginning with June 1959. With the present professional staff at the Centre it is not possible to analyse completely all of these charts and diagrams, and the 700, 500 and 300 mb. charts are analysed for the Antarctic continent and adjacent sub-Antarctic islands at 12.00 G.M.T. but extended northwards to about lat. 30° S. at 00.00 G.M.T. daily. Copies of all microfilms are furnished free of charge to each of the countries associated with S.C.A.R. and to W.M.O. Countries have been advised through their S.C.A.R. delegates that additional copies may be obtained on a repayment basis.

Since September 1959, statements in standard W.M.O. code form describing the topography of the 700, 500 and 300 mb. surfaces over the Antarctic continent and adjacent sub-Antarctic islands have been disseminated within the Australian communications network, and have also been broadcast on the meteorological subcontinental transmissions from Station AXM, Canberra. The time of issue of statements has been dictated by the time of receipt of reports. Except during periods of radio blackouts, statements are issued 30 hours after observing time, and broadcast three hours later. Arrangements have been made for the transmission of the required South African data by radio and cable. This service is operating satisfactorily.

No data are yet being received from the continent of South America. However, in July 1959, the Director-General of the Servicio Meteorológico Nacional of Argentina expected that it would be possible to pass the required data via "Ellsworth" station, and the Director of the Instituto Antártico Argentino has recently stated that communications tests between Buenos Aires and "Ellsworth" are about to be made. He has requested that similar tests be made between McMurdo and "Ellsworth" station and this is in hand. In the meantime, since 1 August, Argentina has been sending copies of its daily surface weather map, together with raw data from the upper pressure levels, at about weekly intervals by air mail.

McMurdo has been intercepting FICOL broadcasts and relaying the messages on to Melbourne. This service began in March 1959, although the degree of success obtained averages only about 40 per cent.

The bulk of Antarctic data is received from McMurdo by way of New Zealand and Sydney. Reports are received direct in Australia from both "Wilkes" and Mawson, the latter also transmitting those reports received from the "daughter stations". Reports transmitted direct from the Australian stations and through McMurdo are received regularly (although at times delays are considerable) but with reports received only through the McMurdo–New Zealand channel the percentage received is quite low. Even for McMurdo, the Antarctic terminal of this major communication link, the percentage of surface reports received over quite a long check period averaged only 76 per cent.

The period between lodgement and receipt of South African reports is four to six hours, which at the present stage of operations is considered satisfactory.

The most serious delay in receipt is with data from the Antarctic continent. Originally the time of 12 hours after time of observation was considered desirable for the issue of analyses. With the present delays in receipt of reports issue of statements at this time is quite impracticable. The percentage of reports received from Antarctica within 12 hours on an average day would not exceed 30 per cent in the case of surface reports and even less for the upper air reports, which are the more important in Antarctica. Approximately 70 per cent of surface reports and about 60 per cent of upper air reports are normally received by 36 hours after observation time.

Recently officers of the Bureau of Meteorology have discussed the communications problem with Australian and United States communicators, including the establishment of a direct communications channel between McMurdo and Australia, following the recommendations of the Third Meeting of S.C.A.R. These matters are receiving continuing attention by officers of the Bureau of Meteorology, Department of Civil Aviation, A.N.A.R.E., O.T.C. and United States Navy. From discussions and experience it seems clear that two reliable communication channels are required between Antarctica and Australia for the transmission of meteorological traffic for I.A.C.C. The S.C.A.R. Working Group on Communications will, it is hoped, evolve a satisfactory plan for Antarctic communications.

Six months after its establishment the Centre is able to produce effective analyses of circumpolar charts.

The main difficulties now facing the Centre are: (*a*) The absence of any reports from the mainland of South America; this is expected to be overcome in the near future. (*b*) The poor quality of Antarctic communications; this will probably not be satisfactorily resolved until the Melbourne–McMurdo channel is in operation. (*c*) The shortage of analysts. The analysis programme of the Centre should occupy up to six experienced professional meteorologists, and every opportunity should be taken to encourage meteorologists of member nations to engage in research work in the Centre. Accommodation is adequate for such workers.

The International Antarctic Analysis Centre has produced the first of the eries of Synoptic charts for the surface 700, 500 and 300 mb. levels for 00.00 nd 12.00 G.M.T. daily, together with plotted time sections for certain selected tations for the month of June 1959. Copies have been sent to each of the ational delegates of the countries associated with S.C.A.R., and to the V.M.O.

Organizations interested in acquiring copies of these charts should apply hrough their national delegates. The cost of each set, despatched by air mail, s £3 per month.

CORRESPONDENCE

A LOCAL SURVEY OF THE EARTH'S MAGNETIC FIELD IN THE VICINITY OF ROYAL SOCIETY BASE, HALLEY BAY

The establishment of geomagnetic observatories on floating ice shelves durin the I.G.Y. presented certain problems not encountered when observatori are built on rock. One difficulty is that ice shelves are normally movin slowly forward in relation to the underlying sea bed. It is therefore necessar to analyse slow changes in the recorded magnetic field at a station in orde to decide the proportion of the change which is due to the movement of th station, and the proportion which represents a genuine secular change of th earth's magnetic field.

At Halley Bay definite movement of the ice shelf has not so far been detecte by astronomical measurements. That movement does take place is howeve confirmed by movement apart of two points on a north–south line, three mile from the ice front, of 1·22 parts in 1000 per year. Also movement is necessar to explain the constant surface level of the ice shelf well clear of the ice fron of 94 ft. (29 m.) above sea level, in spite of a yearly net accumulation about 3 ft. (1 m.) of snow.

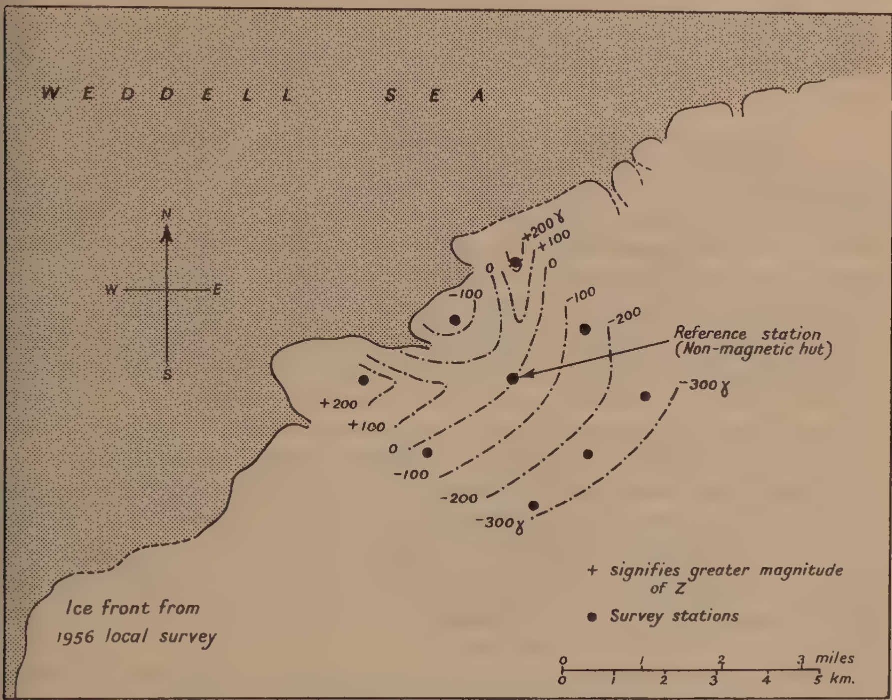
A local survey of the vertical force of the geomagnetic field was therefo made during October 1958. The nine stations occupied covered an area of abou 4 km. square around the non-magnetic hut and the measurements were mad by two observers with a B.M.Z. magnetometer. The sites of the stations we judged by eye to be at roughly the same level. Any difference between th stations was considered less than 10 ft. (3 m.). Measurements were referre to the central station near the north door of the non-magnetic hut after du allowance for changes with time indicated by the variometers.

The following table shows the result of the observations:

Station	Observer J.M.D. (γ)	Observer A.B. (γ)	Mean difference from reference station (γ)
Reference	43,493	43,498	–
North	43,693	43,701	+203
North-east	43,297	43,309	−191
East	43,216	43,215	−278
South-east	43,229	43,233	−263
South	43,203	43,208	−288
South-west	43,473	43,480	−18
West	43,736	43,741	+244
North-west	43,360	43,368	−130
Reference	43,488	43,496	–

The position of the survey points was placed on a map showing the i front in 1956 and isogonals were drawn (see Fig.). It was immediately appare that the isogonals were closely associated with the features of the ice fron

This fact tends to confirm that the features of the ice front were due to geological structure below the ice shelf. This appears to fit the hypotheses put forward by Swithinbank, 1955, after a study of air photographs and a limited number of soundings of the depth of the sea off ice shelves, that although the major part of an ice shelf may be afloat, considerable sections of its seaward boundary may be just aground on shoals.



Survey of geomagnetic vertical force at Halley Bay, 1958.

As the contours of the geomagnetic anomaly are fixed to the geological structure below the ice shelf, a measurement of the absolute movement of the ice shelf is necessary to make small corrections to the geomagnetic secular change. In this connection it was noted that in 1958 the vertical force survey showed the change of field towards the sea was minimal; consequently the site of the observatory was, by good fortune, the best possible one in the small area examined. A measurement of the movement of the ice shelf may be possible by repeating the geomagnetic survey after sufficient time has elapsed for the movement to be detected in relation to the contours.

In view of its simplicity, this method of investigation of certain problems in relation to glaciology and geology is to be commended to future workers in Antarctica.

I am indebted to Mr A. Blackie for his assistance with the Geomagnetic Survey, to the I.G.Y. Expedition's Advance Party for their 1956 ice front

survey, and to The Royal Society for permission to publish these results. The work was done whilst I was seconded from the Meteorological Office to The Royal Society I.G.Y. Expedition.

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11 *August* 1959

ANTARCTIC ICE TERMINOLOGY: ICE DOLINES[1]

Large steep-sided depressions in the glacier ice of the George VI Sound region were reported by members of the British Graham Land Expedition 1934–37 and by aviators of the American "Operation Highjump" in 1947. Fleming (*Geographical Journal*, Vol. 91, No. 6, 1938, p. 512) called the holes "ice calderas" and Stephenson (in Rymill's *Southern Lights*, London, 1938, p. 194) talks of "a crater-like formation". Byrd (*National Geographic Magazine*, Vol. 92, No. 4, 1947, p. 504) used the term "ice volcanoes". Similar, but rather bigger, depressions are found around the borders of the Amery Ice Shelf in MacRobertson Land and a number of them have been photographed by the Australian National Antarctic Research Expeditions.

It is likely that the depressions result from collapse of the surface ice after bodies of englacial water are drained, the mode of formation being similar to that of the smaller holes found on Greenland glaciers. (Details are given in an article by Mellor and McKinnon on p. 33.) The earlier names used for these features are inappropriately suggestive of volcanism and it seems better to draw a parallel with the subsidences which occur in karst country after the collapse of underground chambers. The name "ice doline" was suggested by Dr F. Loewe and I would now like to propose this term as an addition to Antarctic ice nomenclature.

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[1] See photograph facing p. 34.

OBITUARY

Apsley Cherry-Garrard was born in 1886 and educated at Winchester and Oxford. His polar interests began when he was introduced to Captain Scott by Dr E. A. Wilson in 1909, with probably a strong recommendation that he would be a very useful member of the expedition that Scott was then organizing. And that s precisely what he became in spite of the fact that he was not a scientist.

Very quiet and unassuming, "Cherry" took part in every major journey and shared every duty, from out on the yard arms furling sail on the ship to the hardest of sledge journeys, and that in spite of the fact that his eyesight was poor and he had to wear glasses for nearly all his activities.

He was, next to Wilson, the most unselfish sledging companion the present writer ever met, always the first to volunteer for the most unpleasant chores. Fate willed t that he should be in all the close shaves that must occur on such an expedition—drifting out to sea on broken up ice, narrowly escaping the hazards of the famous Winter Journey and going two-thirds of the way to the South Pole.

In the winter at the base hut he helped Wilson at taxidermy, and was appointed as editor of the *South Polar Times*, where he began to show the literary ability which later blossomed into what is probably the best polar book ever written, *The Worst Journey in the World* (London, 1922), a classic to all polar historians. He was a close friend of both Wilson and Bowers, with whom he accomplished that worst ourney.

It was he who, by a series of mischances, was the only officer available to try to meet the returning Pole Party, the ill luck being that his only companion was a rather frightened Russian dog-boy, and that he himself was not a navigator. The Pole Party, being delayed by accidents, was, as we now know, never within relief distance of those two men, but the fact that he did not risk all and, in fact, disobeyed orders, weighed on his mind to some extent for the rest of his life.

Nevertheless he wrote his narrative of the expedition on his return, and became an unusually good water colour painter in the manner of Dr Wilson himself. F.D.

Frits Johansen, the naturalist, was born in København in 1882 and died in 1957. After leaving school he took part in several marine biological expeditions to the Faroes, Iceland and east Greenland before going to Ottawa in 1912. He took part n Stefansson's Canadian Arctic Expedition, 1913–16, and collected biological specimens in Alaska and the western Canadian Arctic. He later worked for the Canadian Department of Marine and Fisheries before returning to Denmark.

Charles Francis Laseron, who died in Concord, Australia, on 27 June 1959, aged 72, had been assistant biologist on Sir Douglas Mawson's Australian Antarctic Expedition, 1911–14. Educated at the Sydney Technical College, he became collector to the Technological Museum and made many contributions to the knowledge of Australian flora, fauna, geology and conchology. He wrote an account of his experiences in Antarctica, *South with Mawson* (London, 1947), and a number of works on Australian geology.

Thorolf Vogt, the Norwegian geologist, was born in Hedemark on 7 June 1888 and died on 8 December 1958. He led expeditions to Spitsbergen in 1925 and 1928, and to south-east Greenland in 1931. In 1939 he became professor of mineralogy and geology at Norges Tekniske Høgskole.

Keith Warburton, together with four companions, lost his life during a climbing expedition which he was leading to the Batura Mustugh range in the Karakoram mountains in July 1959. He was 31 years of age and a widely experienced mountaineer. He had previously climbed in the Himalayas, in 1957, and had accompanied the South Georgia Survey as medical officer and mountaineer during the seasons 1953–54 and 1955–56.

Colin Blair Wilson met a fatal accident at his home in Cambridge about 19 May 1959 in the midst of active preparations for the summer's field work with the Cambridge Svalbard Expedition, 1959.

Born on 24 June 1928, orphaned while still a child, he came up to Emmanuel College, Cambridge, in 1949 and read for the Natural Sciences Tripos, taking Part II in Geology in 1952. The same year he joined his first Spitsbergen Expedition and was introduced to the Hecla Hoek rocks on which he worked till his death. He returned with the Cambridge Spitsbergen Expedition 1953. In 1955, in company with D. Masson Smith, he made long sledge journeys (often solo) throughout Ny Friesland, based on Billefjorden. In 1956, after beginning work with Masson Smith in Ny Friesland going across by boat from the north. Wilson continued alone, undertaking solo sledge journeys and finally a solo boat journey from Wijdefjorden to Longyearbyen. In 1957 Wilson journeyed alone by sea to north-west Ny Friesland, and having completed his immediate observations by sledge journey there, in 1958 worked alone by boat and sledge in Oscar II Land.

These journeys reveal exceptional stamina and he was no mean athlete. His planning was careful, and although he seemed fearless he calculated the risks against the scientific gain and was not foolhardy. His absorbing interest in the Hecla Hoek rocks of Spitsbergen was not linked with any ordinary ambition. It was only latterly that he was persuaded of the value of publishing his results, and happily they are carefully preserved in various stages of preparation, for he was a remarkably keen observer.

Wilson had sufficient private means to be independent of the ordinary routine and conventional opinion. He was generous, lived simply, enjoyed music, read widely, but was first and foremost an investigator and lover of the Arctic scene.

ERRATA

The *Polar Record*, No. 61, 1959

ge 373, line 14. *After* 100 lb. *add* Native dogs when taken over by Europeans increase in weight by about 10 lb. in one or two generations.

ge 374, line 26. *After* Patrol *add* who always span their dogs, and with West Greenlanders

The *Polar Record*, No. 62, 1959

ge 457, line 6. *For* Markham Inlet *read* Clements Markham Inlet

ge 467, line 49. *For* component horizon *read* horizontal component

ge 458, line 30. *For* Parry Islands *read* Melville, Prince Patrick Eglinton, Brock, Borden, and MacKenzie King Islands.

ge 472, line 18. *For* north-west, *read* south-west

line 19. *For* 23 July 1916 *read* 15 June 1916

ge 473, line 1. *For* 30 April 1930 *read* 24 April 1930

RECENT POLAR LITERATURE

This selected bibliography has been prepared by R. J. Adie, Terence Armstrong, T. H Ellison, Amorey Gethin, J. W. Glen, W. B. Harland, H. G. R. King, Brian Roberts an Ann Savours. Its main field is the polar regions, but it also includes other related subject such as "applied" glaciology (e.g. snow ploughs and ice engineering). For the literature o the scientific study of snow and ice and of their effects on the earth, readers should consu the bibliographies in each issue of the *Journal of Glaciology*. For Russian material, th system of transliteration used is that agreed by the U.S. Board on Geographic Names an the Permanent Committee on Geographical Names for British Official Use in 1947 (see *Pola Record*, Vol. 6, No. 44, 1952, p. 546).

Reprints of "Recent Polar Literature", from Nos. 37/38 onwards, can be obtaine separately (to allow references to be cut out for pasting on index cards) from the Institut price 2*s*. 6*d*. for two reprints. Copies will be sent without charge to organizations with whic the Institute maintains exchange arrangements and which notify their wish to receive them Readers can greatly assist by sending copies of their publications to the library of the Institut

To increase the usefulness of the bibliography, entries have been arranged provisionall under subject headings in classified order according to the Universal Decimal Classificatio When circumstances permit the decimal notation will be included, together with a key.

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